

**INNOVATION AND
BUILDING CODES**

**-A Study into
Performance Codes-**

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Performance Codes-**

Prepared for

**Canada Mortgage and Housing Corporation
and
The Technological Innovation Working Group
of
The National Housing Research Committee**

by

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PREFACE

A Guide to the Reader

The authors appreciate that some may find this report too lengthy and time consuming, and may wish to concentrate only on certain portions. To facilitate this, a brief review of the entire project is provided at the beginning of the report. In addition each chapter is provided with a brief summary. The latter are enclosed in boxes at the beginning of each chapter.

If a reader is familiar with the Canadian regulatory process, for example, and the role played by building codes, reading only the summary for Chapter 2 may serve perfectly well. Similarly, the summaries on foreign regulatory processes may suffice for those who are interested more strictly in the domestic regulatory process.

Disclaimer

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ABSTRACT

This study of the building regulatory process was initiated to determine whether or not building codes are unduly inhibiting innovations in construction by virtue of their prescriptive nature, and addresses the issue of whether codes that are more performance based would facilitate innovations.

The effect of the building regulatory process on innovation was examined from three principal aspects: the manner in which codes are written, how they are administered, and the procedures by which new products or systems are evaluated.

The study examined how building codes affected the introduction of innovation in past years, and attempted to obtain current examples from industry where building codes were perceived to be unduly restrictive in allowing innovations.

The basis on which performance requirements are developed, and the various concepts of performance based building codes were examined. It was noted that while some performance requirements can be established relatively simply by comparative testing against proven products, many others involving certain aging characteristics or long term health risks are much more difficult to establish without prior knowledge of the material to be used. Where integrated systems are involved, such as for fire safety, the problem can be even more complex. The role that computer modelling can play in this process was also touched upon.

Building regulations in Australia, New Zealand, Japan, USA, Britain, Norway and Sweden were also compared along with current developments in the EC countries who are preparing for the free flow of goods and services by 1992.

Conclusions

Among the eighteen listed issues addressed, the study concluded that there is little evidence to suggest that current Canadian codes are unduly restricting innovations. It further concludes that while verifiable performance codes are desirable long term objectives, realistic requirements can be developed only to the extent that knowledge is available. Experience with the 1965 NBC showed that non-verifiable performance requirements that depend on "deemed-to-satisfy" solutions are more awkward to use than the current type of code.

The evaluation process has a much greater impact on facilitating or restricting innovations than the form in which a code is written. In spite of this, however, the evaluation and code administration processes could be assisted if the code objectives were clearly stated and catalogued to be readily cross-matched with the requirements.

Abrégé

Cette étude du processus de réglementation du bâtiment a été entreprise pour permettre de déterminer si les codes du bâtiment limitent indûment, de par leur caractère normatif, les innovations dans ce domaine et si les codes davantage fondés sur la performance seraient plus propices à l'innovation.

L'effet du processus de réglementation du bâtiment sur l'innovation a été examiné selon trois grandes perspectives: la façon dont les codes sont rédigés, la façon dont ils sont appliqués, enfin les méthodes d'évaluation des nouveaux produits et systèmes.

On a étudié dans quelle mesure les codes du bâtiment ont influé sur l'adoption des innovations dans le passé, et tenté d'obtenir de l'industrie quelques exemples où elle a trouvé que les codes du bâtiment faisaient indûment obstacle à l'innovation.

Les critères d'élaboration des exigences de performance ont été examinés, de même que les divers paramètres des codes du bâtiment fondés sur la performance. On a remarqué que, même s'il est possible d'établir de façon relativement simple des exigences de performance à l'aide d'essais comparatifs par rapport à des produits établis, d'autres critères sont, en raison de certaines caractéristiques de vieillissement ou de risques à long terme pour la santé, beaucoup plus difficiles à établir sans une connaissance préalable de la matière qui sera utilisée. Lorsqu'il s'agit de systèmes intégrés, comme ceux qui servent à la prévention des incendies, le problème est encore plus difficile à résoudre. Le rôle éventuel de la modélisation informatique dans ce processus a été abordé.

De plus, on a comparé la réglementation sur le bâtiment en vigueur en Australie, en Nouvelle-Zélande, au Japon, aux Etats-Unis, en Grande-Bretagne, en Norvège et en Suède, et examiné où en sont les pays de la CEE, qui se préparent pour la libre circulation des biens et des services en 1992.

Conclusions

Les conclusions qui se dégagent de cette étude sont que, parmi les dix-huit points étudiés, peu d'éléments de preuve permettent de dire que les codes canadiens actuels limitent indûment l'innovation, et que, même si des exigences vérifiables de performance sont des objectifs souhaitables à long terme, on ne pourra élaborer d'exigences réalistes que dans la mesure des connaissances acquises. L'application du CNB de 1965 a montré que des exigences non vérifiables de performance qui reposent sur des solutions réputées satisfaisantes sont moins faciles à observer que le genre de code en vigueur actuellement.

Le mécanisme d'évaluation exerce, sur l'essor ou l'empêchement de l'innovation, un effet beaucoup plus prononcé que la façon dont un code est formulé. Malgré cela, cependant, on favoriserait sans doute les mécanismes d'évaluation et d'application du code si les objectifs du code étaient formulés et catalogués avec une précision qui permette de les rapprocher facilement des exigences.

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- Canadian Standards Association
- Canadian Home Builders' Association
- Ontario Ministry of Housing
- Canadian Construction Materials Centre, (NRC)
- Institute for Research in Construction, (NRC)
- Canada Mortgage and Housing Corporation

The authors also wish to express their appreciation to the staff of the Institute of Research in Construction for their assistance, as well as to the various provincial authorities responsible for provincial building regulations, and various representatives of industry and their associations. The information, insights and instructive comments given so generously by these individuals and agencies contributed significantly to this project.

Portions of various editions of the National Building Code that constitute Appendices C, D and F of this report are reproduced with the permission of the National Research Council.

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SUMMARY

A STUDY INTO PERFORMANCE BUILDING CODES

Background

It has been suggested that the National Building Code (NBC) is too prescriptive, and because of this, innovations are unduly restricted. If building regulations were more performance oriented, would innovations be facilitated, thus making building construction more productive?

To answer this question, Canada Mortgage and Housing Corporation (CMHC) contracted for a study of the regulatory process to examine the degree to which building regulations unduly restrict innovations.

For analytical purposes, the study divided the regulatory process into three components. Building codes form only one of these. The evaluation process for new products and systems, and the administrative process are equally important.

What is Performance?

To provide a common basis for understanding the issues, it was first necessary to examine various code concepts. In some building regulations, the requirements are stated in specific performance levels that can be verified and enforced (e.g. design loads, fire resistance, sound resistance). In others, the requirements are stated in performance terms that cannot be verified (e.g. adequate, safe, sufficient). These may be supplemented by "deemed-to-satisfy" documents. Prescriptive requirements, on the other hand, provide a ready-made design solution. In most cases, building codes, including the NBC, are a mixture of both performance and prescriptive requirements.

National Building Code

While many NBC requirements are expressed in prescriptive terms, provision is made to allow alternative solutions if equivalency can be established.

The reliance on reference standards (now 210 in number) to regulate buildings is increasing with each new code edition. The performance or prescriptive nature of the NBC is to a large extent determined by the nature of these standards.

The NBC experimented with non-verifiable performance requirements in 1965. Part 9 specified such requirements, and the Residential Standards showed how they could be met. Part 9 was not enforceable in itself, and users could not see the point of having the effective requirements under a separate cover.

A number of verifiable performance requirements developed as a result of extensive research were more effective. These were initiated as a result of market driven forces.

Establishing Performance Levels

The difficulties of establishing realistic performance levels were reviewed, from the relatively simple cases involving structural comparisons with traditional systems, to the more difficult cases involving products with potential long term health risks. Even more complex are performance requirements for integrated systems such as for fire safety where the performance level of one component can affect the level required for other components.

Advances being made in fire technology and computer modelling were reviewed, including those pioneered at the National Institute for Standards and Technology (formerly the National Bureau of Standards). The implications of a fire safety assessment model being developed jointly by Australian and Canadian researchers for residential buildings was examined, along with the building code assessment framework study sponsored by NRC and the Ontario government. While showing promise for future code rationalization, these programs are in a relatively early state of development.

Reference Standards

Trends in reference standards were also examined. Like the NBC, most standards are a mixture of both performance and prescriptive requirements. New performance standards are slow in developing. These are also generally market driven.

New Product Evaluation

Since most new products gain access to the building market as a result of an evaluation process rather than through recognition in building codes, such evaluation is considered to be a key element in facilitating innovations.

The evaluation process in Canada was examined, starting from the "acceptance" program initiated by CMHC for National Housing Act purposes, to the current "evaluation" system provided by the Canadian Construction Materials Centre (CCMC), operating out of the National Research Council (NRC). Provincial systems, which give local approvals, were also reviewed. The role of other agencies in the evaluation business, including the Canadian Standards Association (CSA), the Canadian General Standards Board (CGSB), the Canadian Gas Association (CGA) and the Underwriters' Laboratories of Canada (ULC) were also noted.

A review of significant product innovations introduced in the postwar period showed that most of these were introduced after they were evaluated and listed by CMHC, with existing building codes playing a relatively minor role in the process.

Administration

The third major component affecting innovations, the manner in which the Code is administered, is influenced by the technical training and attitude of local officials, and the assistance available in carrying out day-to-day code enforcement.

Both were found to vary from province to province. In some provinces extensive services were available including product evaluation, inspector training, code interpretation, workshops, seminars and newsletters. In others, practically no assistance was available, and the local officials operated virtually on their own. The role played by NRC in this process was also noted.

The powers granted to local officials in allowing alternate design solutions to be used, was an important factor in facilitating innovations. The absence of this authority can cause proponents to perceive the code as being unduly restrictive. This perception can also occur

with improperly trained local officials.

Provincial Views

Provincial agencies responsible for building regulations were asked a series of questions covering a number of subjects. While a majority of the ten provinces did not consider their building codes to be too restrictive, several provinces considered that a conversion to a more performance based code would facilitate innovations.

The provincial authorities also reported on assistance provided to local officials, the training programs provided for building officials, and provincial product evaluation policies.

Industrial Experience

A number of industry associations, builders, and building product manufacturers were contacted regarding their personal experiences with the restriction of innovative products. While the response was limited, it seems to indicate that there were few perceived problems in relation to traditional materials and systems. The small number of complaints that were received affected the use of newer materials. Some of these are considered to be related to the evaluation process rather than the NBC. Some appeared to be disagreements with the level of required performance, or were related to the administrative process. It was not obvious how performance requirements per se would have facilitated innovation in most of these cases.

Foreign Codes

A review was made of building regulations in Australia, New Zealand, Japan, United States, Norway, Sweden, England and Wales. In addition, the steps now being taken to harmonize regulations to facilitate the free flow of goods and services between European countries by 1992 were reviewed. Although there was an obvious trend towards performance codes, these appeared to either arise from general dissatisfaction with existing regulations or to ease the process of harmonization.

Conclusions

The conclusions of this study address the following issues:

1. **Are regulations too restrictive?** No matter what regulatory or approval system is established it will present some degree of restrictions to innovation. (If this were not the case, there would be no need to have any type of building regulations). The question to be answered, therefore, is the degree of restriction justified in terms of the performance objectives.
2. **Does the NBC restrict innovations?** There is little evidence that the prevalence of prescriptive requirements in the NBC has in itself seriously inhibited the introduction of innovations in construction.
3. **Are drastic code changes warranted?** While certain examples have been brought to light of perceived undue restrictions to new products, where a "performance approach" in the NBC may have facilitated the evaluation process, it is doubtful if these examples would warrant a revamping of the current approach.
4. **Why are other countries changing?** The literature indicates that in a number of countries where a complete overhaul of the building code was undertaken (NZ, UK, Australia) it came about as a result of general dissatisfaction among code users. There does not appear to be the same groundswell of criticism of the National Building Code.
5. **What are the effects of performance codes?** While there has been a move toward a conversion to performance building codes in a number of countries, it is premature to assess the effect of this conversion on the construction industries in those countries.
6. **Are codes unduly blamed for restrictions?** When a proponent faces restrictions, there may be a tendency to blame "the building code" regardless of the real cause for the restriction. Whether the restriction is due to the approval process, to the enabling provincial legislation or to the lack of experience of the administrator makes little difference to the proponent. All can be perceived to be due to "the building code".

7. **Why train building officials?** The important role played by local building officials in facilitating or restricting innovations requires that such positions be filled by adequately trained personnel to encourage the judicious application of building code requirements.
8. **Are performance codes attainable?** While the development of a verifiable performance based code to supplant the current NBC is not a practical short term objective, the development of verifiable performance requirements could be pursued as a long term objective of the ACNBC. If such an objective were made known to the technical committees, they would be able to develop priority ratings consistent with available resources. Since standards form an integral part of building codes, these comments obviously apply to all codes and standards writing committees.
9. **What limits their development?** Verifiable performance requirements, if they are to be reasonable and realistic, can only be established to the extent that there is sufficient knowledge to do so. Arbitrary performance numbers without a knowledge foundation to justify them can lead to unnecessary costs or constraints if they are too conservative, or a decrease in safety if they are not conservative enough.
10. **Are non-verifiable performance codes practical?** The conversion of the current NBC requirements to a series of non-verifiable performance generalities that depend exclusively on other documents for deemed-to-satisfy solutions (similar to the UK and NZ approaches) serves no practical purpose, and may in fact make the NBC unenforceable. As was shown, this has already been tried in Canada in the 1965 NBC with little success.
11. **How should performance requirements be introduced?** Where performance requirements are introduced, it is important that there be as little disruption as possible to code users. "Deemed-to-satisfy" solutions are therefore generally retained from existing requirements as an option to satisfy such performance levels. Practical considerations to facilitate code implementation dictate the need for "deemed-to-satisfy" solutions whenever performance requirements are used.
12. **How should codes be written?** Whatever form a requirement takes, it is obviously advantageous to the code user that it be expressed clearly, allow alternative solutions,

and satisfy its objective in the most cost effective manner.

13. **Can other aids be found to help code users?** The evaluation of alternatives or equivalencies can be assisted by clear statements that explain the objectives of individual NBC requirements. While many such areas are currently covered in the appendix to the code and in the commentaries, these are not complete nor is there a consistency in format that allows an easy match to be made between the requirement objective and the requirement.
14. **What should be in codes and what should be in standards?** There appears to be no consistent policy regarding the type of material to be included in the National Building Code and the material that should be in referenced standards. It would be useful for writers of codes and standards if the advantages and disadvantages of having detailed requirements in the code or in separate standards were determined in the light of the use of the code by designers or builders as well building officials. Where there is little advantage of retaining detailed requirements in the code, appropriate reference standards can be used. Where the requirements are considered to be more appropriate as code requirements, there is little justification to require the code user to refer to another document. If the standards writing agencies are made aware of such policies they would be able take appropriate action.
15. **Are code writing and product evaluation related?** The CCMC evaluation service and IRC's Codes Section have complementary goals in defining the objectives of code requirements. The former must know these in order to determine if a product conforms to the code while the latter requires this knowledge to be able to draft the code requirements. Both can learn from the experiences of the other and thereby facilitate the move towards verifiable performance requirements.
16. **How can the NBC be improved?** While the NBC has not been demonstrated to be unduly restrictive to innovations, there are obvious areas where improvements can be made in the manner in which requirements are expressed to improve its comprehension by users. (Australia is currently examining its code in this light.)
17. **What is the most important factor affecting innovations?** The natural path for the introduction of innovations is by an evaluation process rather than by way of code

recognition. Some innovators, however, are frustrated with the length of time required for evaluation, and with what they perceive as unnecessary demands for additional product testing. Therefore, the improvement and further development of a process that is perceived by the innovator as being accessible, fair and open to appeal, has obvious inherent advantages . **The evaluation component indeed appears to be the key ingredient in the regulatory process facilitating or inhibiting innovations.** The manner in which this function is carried out can have an effect on innovations to a far greater degree than the manner in which a code requirement is expressed, particularly in the light of the equivalency requirements in Section 2.5 of the NBC.

18. **What about administrative costs?** Several countries have become concerned about the cost of administering building regulations, and are exploring alternative arrangements, including privatization. This subject is also under review by a number of provinces. Information on such costs does not appear to be readily available to allow cost comparisons of alternative administrative systems to be made. This is an area requiring further study.

A STUDY INTO PERFORMANCE BUILDING CODES

1. GENERAL

Summary:

If building regulations are too restrictive, they will inhibit innovations and build unnecessary costs into construction. CMHC sponsored this study to answer the questions whether current Canadian Codes are too restrictive, and whether performance codes would facilitate innovation.

The building regulatory process consists of three main components: the code requirements, the evaluation process for new products, and the administrative process. All three are examined here. The study draws upon the literature, interviews with appropriate IRC/NRC staff and foreign code experts, and communications with industry as well as provincial building code authorities.

Performance codes are of two main types: those with verifiable requirements that are measurable, and those with non-verifiable requirements that are not (eg safe, adequate, satisfactory). Performance codes are generally accompanied by standards or other documents that provide deemed-to-satisfy solutions.

Prescriptive codes, providing specific design solutions, are easier to write and to use, but generally do not allow a choice of design. Most codes are a mixture of performance and prescriptive requirements.

The majority of provincial authorities tend to believe that current building codes are not unduly restrictive. Most also indicate however that performance codes would facilitate innovations.

Support services provided by provincial authorities to municipal building officials varies widely from province to province. They range from practically nothing to a wide range of services that include education, information, interpretation and evaluation services.

Most authorities were of the opinion that the Canadian Construction Material Centre (CCMC) will help facilitate innovations although some remain sceptical.

1.1 Introduction: Building construction is the public's business

Experience has shown that the design and construction of buildings must be regulated to protect the health and safety of people who use them. Just as society must have laws to

protect innocent people against the excesses of the more predatory elements of society, so must building users be protected by building regulations against the ill-informed and unscrupulous practitioners within the building industry.

In fairness to all, the degree of regulation should be the minimum amount necessary to attain the desired level of protection. More than this will subject the industry to unnecessary hindrances that will be reflected eventually in reduced productivity to be paid for by all users.

A major challenge of this project is to assess whether or not Canadian building regulations have crossed over this line, and are in fact causing undue restriction to business enterprise.

1.2 The Basic Issue: Is the regulatory process still unduly restrictive?

It has been suggested by some that Canadian building codes may be too material-specific in regulating buildings, and that this prescriptive approach in itself has an inhibiting effect on building innovations. Is this so? If the codes were more performance oriented, would this have a beneficial effect on building innovation, ultimately enhancing productivity? This is the essential issue to be addressed.

Building codes are for the protection of the health and safety of the occupants. They are not, or at least should not be, a vehicle for legislating legitimate products into or out of the market. Ideally, codes should accomplish their prime function in the most cost-effective manner. If a code inhibits changes that would allow requirements to be met more cost-effectively, then it defeats that purpose and imposes an unnecessary financial burden on society.

1.3 The Study Method: Trace and project the trends and effects of the Regulatory Process

So much has been written on building regulations over the years, that any attempt to make a comprehensive literature review of this subject would be futile. This study confined itself, therefore, to the more recent literature, and to the authors and sources whose reputations are known and respected.

Considerable assistance was provided by a number of experts at the Institute for Research in

Construction who gave freely of their time in reviewing the subject as it applied to Canada and elsewhere. The authors gratefully acknowledged their assistance to the project.

The views of various provincial building authorities were also solicited in an attempt to give a provincial perspective to the current status of building regulations. The study also attempted to establish the extent to which building regulations were perceived by industry to be unduly restrictive, particularly to innovations. Industry and industry associations were contacted, and through the latter, many additional contacts were made with their membership.

Building regulations in a number of countries were reviewed to provide a perspective of their trends, and an appreciation of the various forms that building regulations take. This information cannot be easily applied, however, due to the difficulty in assessing such regulations from another country's perspective.

Canadian building codes were reviewed in the context of the total regulatory process: from zoning at the local level, to the effect of various provincial and federal acts that also impacted on building construction.

Canadian building codes were examined not only in relation to their content, but in relation to how they were administered, and the evaluation processes available to code administrators.

Canadian experiences with both verifiable and non-verifiable performance requirements were examined. In addition, the role that Canadian codes played in the postwar period during the introduction of many new products and systems was assessed in relation to the CMHC acceptance program in place at that time.

The role that referenced standards play in regulatory process was noted as well as trends towards performance and prescriptive requirements.

The effect of recent European trade agreements on product standards, and their eventual effect on existing building regulations were examined.

Certain long-term world trends were reviewed that could affect future building construction practices. The effect that these could have on future code changes were speculated upon.

Draft reports of this study were distributed for review to the following:

1. Members of the Associate Committee on the National Building Code,
2. Members of the Provincial/Territorial Committee on Building Standards,
3. Members of the Canadian Construction Research Board,
4. Staff of the Institute of Research in Construction serving the ACNBC and the Canadian Construction Materials Centre,
5. The Canadian Home Builders Association,
6. The Canadian Manufactured Housing Institute,
7. The Canadian Standards Association,
8. The Canadian General Standards Board,
9. The Standards Council of Canada,
10. The Working Group on Technical Innovations of the National Housing Research Committee, and
11. Canada Mortgage and Housing Corporation.

Of approximately 100 copies of the draft report that were distributed, only six reviewers submitted comments. These were reviewed prior to completion of this final report.

The draft report was also submitted for review to Informetrica Limited, a firm of consulting economists in Ottawa. Their comments are included as Appendix G of this report.

1.4 The Regulatory Process is much more than just the building code

The regulating process has at least 3 major components: (1) the regulations that have to be followed, (2) the administration component of the enforcement agency, and (3) the ancillary mechanisms for evaluating new products and systems.

A technically competent municipal building inspection department armed with the legal tools to make discretionary judgements on equivalencies is in a much better position to make constructive contributions to facilitate reasonable code enforcement than one which is not. Few complex buildings are constructed, or materials or components introduced, without such regulating assistance. The competence level of the enforcement agency, therefore, can contribute to the success or failure of many projects, the level of innovative thinking which may come forward, and the facility with which innovations are permitted. "Competence" must include an attitude of openness to change.

The mechanism for evaluating and approving new materials, products and systems is certainly important. This is a particularly challenging responsibility and requires a high level of technical competence to deal responsibly with proposed innovations.

The building regulations themselves are of course an important component. The care and thoughtfulness in the drafting of such regulations, along with the objectives embodied in the requirements, can have a significant impact on the innovation process. Not only is this true regarding technical requirements, but it applies to the administrative requirements that assign powers and responsibility to the enforcement agency. In this analysis of the regulatory impact of codes, due consideration will be given to these three components and how they relate to one another.

1.5 Performance Code or Prescriptive Code: Shades of meaning

Perhaps no other building term has so many personal interpretations as the term, performance code. To many, it is associated with all that is desirable and good in building regulations, allowing designers a freedom of choice to attain the desired code objectives. Prescriptive codes, on the other hand, have become associated with arbitrary design solutions that do not allow for alternatives, innovation or evolution. In fact, however, neither type of code exists in its pure form. Most codes are a mixture of the two.

The general public may have its own view of performance requirements. The typical consumer tends to relate performance requirements with the efficacy of the product in performing its intended task, or perhaps relate the term to energy use or durability. More often than not, when a consumer expresses a wish for additional "performance" standards, the concern is for how the product performs rather than how the requirements are expressed. Both should be, of course, essential objectives of a performance based code.

Types of Performance Codes: Performance requirements can be stated in many forms with varying degrees of generality or specificity. The degree of each in a particular requirement will help determine its ultimate usefulness and enforceability.

A requirement expressed as a generality, without a measurable level of performance, is practically impossible to interpret or enforce. While such requirements theoretically allow the designer freedom of choice, this is of little practical value if the performance level cannot

be quantitatively determined.

A non-specific, or non-verifiable, performance requirement could be expressed as "a building shall provide a reasonable degree of fire safety". or "a building shall be capable of safely supporting all anticipated loads". A specific or verifiable performance requirement, on the other hand, might be stated as "a fuel fired furnace shall be located in a fire compartment with a one hour fire resistance rating", or "a beam shall be designed to support a design load of 2.0 kPa without exceeding the design stress in a particular design standard".

There are various ways that verifiable performance can be expressed. In the preceding example, for instance, the requirement could have been expressed in terms of a specific test loading conducted in conformance with a particular test standard. It could also have been expressed in terms of load occurrence probabilities and consequence of failure.

To some, a performance requirement also carries the implication of reasonableness. That is to say, the performance level if stated must be realistic. This concept, however, is not implied when the term is used in this report. Performance requirements when expressed in verifiable terms can be reasonable or unreasonable, in the levels required.

A more complete discussion of the various forms of performance requirements can be found in Reference [1]. The measures by which performance requirements are established are discussed in Chapter 3.

Regardless of what term is used to describe the type of building regulation, there is little doubt that the objectives should be to allow the maximum degree of innovation and design freedom to attain the required level of performance.

1.6 Prescriptive Codes Do Work... and market-driven innovation does occur

While restricting design choices, however, prescriptive requirements offer a number of advantages. They are relatively easy to formulate, can be readily understood and interpreted, and most important of all, are relatively easy to enforce. If a requirement is not enforceable, either because it is not measurable or is excessively complicated, it is of little use in furthering the prime code objectives of ensuring minimum standards of health and safety. There is therefore a natural tendency for codes and standards to be written in prescriptive

terms, even though there may be no intention on the part of the code writers to be restrictive of alternative design solutions.

A prescriptive requirement, for example, might be stated as "a fuel-fired furnace shall be surrounded by at least 150mm of solid concrete", or "a living room floor shall be framed with 38mm x 35mm wood joists spaced not more than 400mm on centres." The design solutions in each case is given and no other permitted.

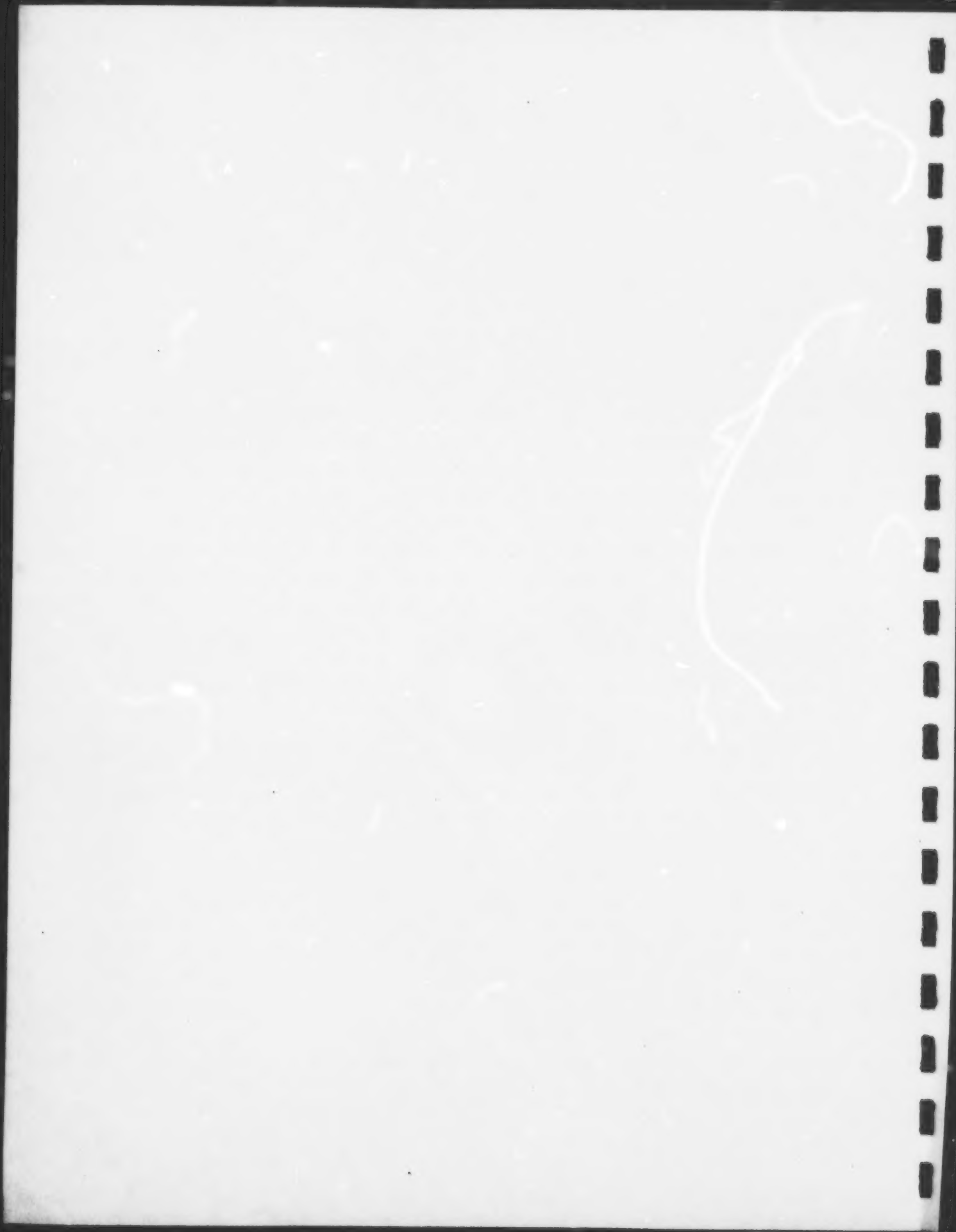
1.7 What the Provinces Think

Since the regulation of building is a provincial responsibility, it was considered important to this study to have the reaction of provincial authorities to the form in which building code requirements are currently written. Accordingly therefore, contact was made with each of the provincial authorities responsible for regulating building construction. Seven specific questions were posed requesting provincial views on the NBC, and on the support services provided by provincial agencies to local jurisdictions. All provinces responded to the request. A summary of the responses is given in Appendix A.

The majority of provincial agencies did not believe that provincial building regulations unduly restrict innovation, although this attitude was by no means universal. The question of whether innovations would be facilitated if the code were written in performance terms was also met with differing views although the majority in this case thought they would.

The answers provided with regard to support services for municipalities indicated a wide range from province to province. In some provinces there are essentially no support services, while in others, the services are well organized and wide ranging.

Most provinces were of the opinion that the Canadian Construction Materials Centre (CCMC) will be a help in facilitating innovations. Some, however, were sceptical, and thought there would be little difference.



2. THE BUILDING REGULATORY PROCESS IN CANADA

Summary:

Building codes form only part of the building regulatory system. Fire, plumbing, electrical, elevator, and gas codes as well as zoning bylaws and other acts passed at the provincial and federal levels also play a part.

Innovations have always been permitted under the NBC if adequacy or equivalency could be proven. Past NBC experience with non-verifiable performance requirements were not successful. The current code is a mixture of verifiable performance requirements and prescriptive requirements.

The NBC increasingly relies on other referenced standards. The performance or prescriptive nature of the Code is affected by the nature of these standards. Although some have been written as performance requirements, most are generally prescriptive in nature.

The training and attitude of local building officials and the support services available can affect the perception of the codes themselves as being too restrictive. Support services vary widely from province to province. When local officials are able to decide on equivalencies, innovations can be facilitated. The absence of such discretionary authority can also cause the Code to be perceived as being unduly restrictive.

The evaluation machinery to assess innovations is an important component of the regulatory process. Most new products access the building market this way. In past years, the central evaluation services played a more important role in influencing innovations than building codes.

A current survey of industry indicated only a few cases of perceived undue restrictions on innovations. These involved new materials. In most cases where this was due to code requirements, it was the required level of performance, rather than the prescriptive or performance nature of the requirement, that was the cause for complaint. In other cases the restriction was due to the evaluation or administration process.

2.1 Several Tools in Several Hands

Although this study is concerned chiefly with the regulation of buildings through building codes, it should be appreciated that these are not the only legal instruments for regulating buildings. Buildings, in fact, are regulated by an array of codes, standards, regulations,

bylaws and acts which vary from province to province, and even from municipality to municipality. This section provides an overview of the regulatory process, and shows the interrelationship of building codes to these other requirements. This section, therefore, serves as an introduction to the sections that follow, so that the reader will have an appreciation of the entire regulatory process, and the role that building codes play in it. The following material draws heavily on material prepared by the National Research Council [2].

Under Canadian law, the regulation of building construction is the responsibility of provincial governments, who in turn can delegate this power to their municipalities. The federal government, however, becomes involved in building regulations in a secondary role when an act (such as the National Housing Act) requires that buildings be built to certain standards in order to qualify for the provisions of the Act. Another federal act, the Hazardous Products Act, regulates a number of building products to limit their risk in relation to fire, health or personal injury. These products include cellulose insulation, urea formaldehyde foam insulation, carpeting, furnishings, smoke alarms and glass used in doors. Regulations under this act take precedence over provincial acts, although provincial requirements can still apply if they are not in conflict.

Terminology: Acts are the legal statements passed by a legislature or parliament that empower the government to carry out particular objectives. These acts are often referred to as the enabling legislation. The terms of an act may give the government the authority to provide regulations to complement the act. In the case of building regulations, the administering authority may prepare these additional regulations utilizing existing published codes and standards to the extent that this is practical (and amend them as necessary). The National Building Code, the Canadian Plumbing Code, the Installation Code for Natural Gas Burning Appliances and Equipment and the Canadian Electrical Code are examples of such codes. The regulations in their altered form may then bear the name of the province even though based on a national code or standard.

Code requirements often reference other codes and standards since it is not practical to include all of this material in the same code. The National Building Code (NBC),[3] for example, references 210 different codes and standards published by seven different standards writing agencies. Some of these are as voluminous as the NBC itself, and may in turn reference additional documents.

The terms "codes" and "standards" are commonly used interchangeably. In general, a document is referred to as a code if its title proclaims it as such. Although there appears to be little philosophical difference between the two types of documents, the term "code" is generally restricted to larger and more complex documents.

Laws passed by municipalities are bylaws. The authority that a municipality can exercise depends on the enabling legislation under which it operates. In provinces that have adopted provincial building regulations, for example, municipalities are usually not permitted to pass bylaws that contravene the spirit of the provincial act.

Building Codes: Building codes are generally concerned with matters affecting fire safety, structural sufficiency and health. They are intended to apply to the construction of new buildings and the demolition or relocation of existing buildings. They are also intended to apply when the use of a building changes or if the building is significantly renovated or altered.

Building codes are increasingly being used to achieve objectives beyond the traditional concerns of health and safety. Most building codes (including the NBC) now contain requirements designed to make buildings more accessible to the disabled. Requirements to make housing more burglar resistant have recently been introduced. Some provincial building codes also contain requirements related to energy conservation, although these have not been included in the NBC. Instead model energy conservation requirements have been issued under separate cover [4]. In Quebec, a separate act regulates energy conservation in buildings and the regulations under the act are based on these model requirements.

The National Building Code was first published in 1941 to encourage reasonable and uniform standards for health and safety in buildings. It is a model, and has no legal status unless it is adopted by an authority having the power to regulate buildings.

Prior to the 1970s, provinces generally delegated the responsibility of regulating buildings to municipalities. Subsequently, however, provincial codes began to replace municipal building bylaws. Most provinces now have acts to regulate building construction, and the regulations under these acts are based in whole or in part on the NBC. In provinces without provincial building regulations, the NBC is usually the basis for municipal building bylaws either by choice of the municipality or as a condition under a provincial act. A summary of

the status of the NBC in each of the provinces is listed under Appendix B.

In addition to numerous references to other codes and standards, the NBC makes frequent references to its Supplement [5] which contains climatic and seismic information for various municipalities across the country, enabling the code to be applied to these areas. It also contains information on the calculation of fire resistance, various measures for achieving fire safety in high buildings, and explanatory material relating to structural design requirements.

Specialized structures such as farm buildings and mobile homes may be regulated under building code provisions or through separate acts that may utilize codes or standards specifically written for such structures.

While the application of building codes to new buildings is fairly straightforward, their application to existing buildings requires additional judgement [6]. It is for this reason that some provinces, such as Ontario, have special provisions in their regulations to deal specifically with existing buildings. These provisions generally permit a relaxation of the requirements that would otherwise apply, while attempting to maintain an acceptable level of safety.

Fire Codes: Fire codes generally apply to buildings already in use. They regulate the conduct of activities that cause fire hazards as well as the maintenance of fire safety equipment and egress facilities, the combustibility of furnishings, and the storage of flammable and dangerous materials. The objectives of the requirements are to prevent fires, particularly those that may present a hazard to the community.

Fire codes and building codes have a number of common objectives, and are usually developed cooperatively.

The National Fire Code (NFC), now in its sixth edition [7], was first published in 1963 to encourage uniformity in fire prevention bylaws. It is used in most provinces either as a basis for regulations under the various fire prevention acts or as guidelines for authorities who administer these acts. Where provincial fire codes have not been adopted, the NFC forms the basis of many municipal fire prevention bylaws.

While building codes are generally administered by building departments, fire codes in most

provinces are administered by the fire services. Each province has a fire marshal or fire commissioner (or the equivalent) whose office is generally responsible for administering fire prevention acts. (In Quebec, the role of the *Directeur général de la prévention des incendies* is somewhat different.) The municipal fire service normally acts on behalf of the fire commissioner or the marshal to enforce fire prevention regulations. The specific roles of the building and fire departments vary from province to province, but generally both cooperate in areas of common interest.

Provinces also maintain "housing corporations" to administer provincial housing programs and provide input into joint federal-provincial programs. They may also own and administer public housing constructed to meet particular provincial objectives. Provincial housing corporations may have additional construction requirements aimed at providing greater durability or lower maintenance and operating costs. Municipalities may also have their own housing maintenance bylaws that apply to existing residential buildings.

Zoning Laws: Municipalities are permitted by provincial acts to enact municipal zoning bylaws. Generally administered by planning departments, the bylaws control the appearance, use and character of neighbourhoods within a municipality. They regulate such things as building size, land use (including type of occupancy), front and side yard clearances, population density and sometimes even landscaping and the exterior appearance of buildings.

Other Codes and Standards: While the bulk of requirements that regulate building construction are contained in building and fire codes, buildings may also be subject to other acts targeted for specific building types or occupancies. Other acts may regulate particular services or equipment in buildings that are not directly regulated by provincial building codes.

Provincial liquor licensing acts, for example, may contain certain building requirements that have to be met before a licence is granted. Other acts may be aimed at providing a minimum level of fire safety in certain classes of buildings (such as hospitals, theatres, schools, or apartments), when it is considered that they are not adequately covered in existing provincial fire prevention acts.

Plumbing may also be regulated by a separate act. The Canadian Plumbing Code[8] contains model plumbing requirements which are used by a number of provinces and municipalities as the basis for their plumbing regulations or bylaws.

Electrical installations are often administered by a separate department. In some provinces the provincial electrical utilities administer the requirements on behalf of the government.

The Canadian Electrical Code, Part 1, is used by all provinces as the basis for their provincial electrical regulations. Like other model codes, it has no legal status unless adopted by an authority having the power to regulate electrical installations. First published in 1927, the CEC is now in its 14th edition [9].

Separate provincial acts may control the installation and maintenance of other building services and equipment such as gas installations, elevators, escalators, moving walkways and pressure vessels. The regulations under most of these acts rely on codes and standards published by standards writing agencies.

Since different acts may have different objectives, the requirements contained in their regulations differ and in some cases may even conflict with one another. Where more than one act regulates the same building, however, the general principle is that each must be satisfied. (There is an ongoing program in most provinces to minimize overlapping regulations and remove conflicts.)

Codes and Standards Writing Agencies: The National Research Council of Canada, through its Associate Committee on the National Building Code, is responsible for producing the National Building Code, the Canadian Plumbing Code, the Canadian Farm Building Code, Measures for Energy Conservation in New Buildings, and other code-related documents. Another NRCC committee, the Associate Committee on the National Fire Code, is responsible for the National Fire Code. Unlike other codes and standards writing organizations, NRCC is a federally funded research agency. It does not operate a general standards writing organization, nor does it provide a certification service for building products. It does, however, maintain an evaluation and listing service through its Canadian Construction Material Centre (CCMC).

The Canadian Standards Association produces most of the codes and standards referenced in the National Building Code including the Canadian Electrical Code. CSA is a non-profit, non-government agency that not only prepares standards but maintains a testing, certifying and listing service for various products including electrical products.

The Underwriters' Laboratory of Canada is also a non-profit, non-government standards writing agency providing a testing, certification and listing service. ULC standards generally apply to products or systems related to fire safety.

The Canadian General Standards Board is a government-sponsored agency operating under Supply and Services Canada. Originally conceived to prepare specifications for government purchasing requirements, it currently operates as a national standards writing body, preparing standards for general use in a variety of fields and maintains a certification and listing service.

Gas appliances and installation standards are prepared by the Canadian Gas Association who also test, certify and list gas-associated products.

Standards produced by the American Society for Testing and Materials and the National Fire Protection Association are also referenced in regulations or codes where there is no acceptable Canadian equivalent. NFPA produces many standards in the fire protection field and, like ASTM, has an international reputation for excellence. Both NFPA and ASTM are non-profit agencies operating in the private sector.

2.2 The National Building Code...allows innovative new materials and methods:...

Special provision to allow for innovative materials and systems has been a tradition of the NBC since its inception. Provision for equivalencies was specially noted in the introduction to the 1941 NBC to draw the attention of the code user to this fact. The introduction noted that:

"In the past, building codes have frequently impeded the introduction of new and improved methods of construction. The National Building Code will not have that effect. Article 3.1.3 makes provision in general terms for the introduction of new materials and methods of construction. These will be supplemented by the publication from time to time of revisions and additions to the Code".

The original equivalency requirement merely stated that:

"Material and methods of construction not specifically regulated by this Code may be permitted provided their suitability and safe working stresses have been approved by the authority having jurisdiction on the basis of laboratory tests carried out by a publicly owned or other recognized laboratory".

While this equivalency clause has undergone many changes from edition to edition, the intent of the current version in Section 2.5 remains essentially the same: to allow for the use of alternative materials and systems.

If a performance code is defined as one whose requirements are expressed in terms of end objectives rather than in terms of the means for achieving them, the NBC could scarcely qualify as such a code. While many requirements are indeed expressed in terms of end objectives, most are not. It would not be classified as a prescriptive code either, however, if this term is intended to imply that the requirements are expressed as specific design solutions without recourse to alternatives. As will be seen later, such is not the case.

It may be more appropriate, therefore, not to judge the NBC by labels that carry with them so many preconceived attributes. Rather, it should be judged in terms of whether or not design alternatives are permitted, whether or not end performance is clearly stated, and whether or not the requirements are rational and reasonable (based on required performance whether stated or just implied).

While engineering design is usually associated with larger buildings within the scope of Part 4 of the NBC, all buildings, including houses, can be designed by engineering principles if the designer elects to do so.

Article 9.4.1.1. states that:

"Except as provided in -----, structural members and their connections shall be designed in conformance with Part 4".

(The exceptions are to allow lesser design loads or a more simplified design procedure if the design option is chosen, since the buildings in Part 9 are smaller and the occupancies less critical.)

The Article further states that:

"When structural members and their connections conform to the requirements listed elsewhere in this Part, it shall be deemed that the structural design requirements have been met".

In other words, the primary requirement for structural members in Part 9 is that they be "designed" to support the stated loads. The detailed structural requirements for

foundations, wood frame and masonry construction in Part 9 are, in effect, "deemed-to-satisfy" requirements. The fact that they are provided as part of the NBC, and not in a separate document is purely a matter of convenience and arrangement. While the design option is seldom exercised in conventional construction, it nevertheless is available to be applied when needed to design or evaluate alternative structural elements or systems.

The prescriptive structural requirements in Part 9 are based largely on practices that have evolved through years of trial-and-error experience. These are often less conservative than designs arrived at through conventional engineering design, although such conventional procedures were also used to some extent to rationalize many of the structural requirements in Part 9. By using the deemed-to-satisfy requirements in Part 9, therefore, not only are potential savings possible in the design solution themselves but in the saving of professional fees as well. It is in fact fairly common practice for designers to provide additional fire walls to compartment larger buildings into smaller floor area segments in order to take advantage of the rule-of-thumb, or "prescriptive" requirements in Part 9 for more economical construction.

The principal requirements that govern the use of new products, systems or alternative design solutions, however, are found in Section 2.5, "Equivalents". This section applies to all buildings, regardless of size or type of occupancy, and to each requirement. The first Article of this section states that:

"The provisions of this Code are not intended to limit the appropriate use of materials, appliances, systems, method of design or construction procedures not specifically described herein."

(This may be considered more as a statement of intent rather than a requirement.) The second Article of Section 2.5 goes on to state:

"Any person desirous of providing an equivalent to satisfy one or more of the requirements of this code shall submit sufficient evidence to demonstrate that the proposed equivalent will provide the level of performance required by this code."

The most important requirement, however, is in Article 2.5.1.3 which states:

"Materials, appliances, systems, equipment, methods of design and construction procedures not specifically described herein, or which vary from the specific requirements in this Code, may be used if it can be shown

that these alternatives are suitable on the basis of past performance, tests, or evaluations".

The code, therefore, clearly indicates that alternative design solutions are indeed permitted, provided that evidence demonstrates equivalency or adequacy of performance. If this is in fact honoured, therefore, the NBC cannot be considered to be exclusionary since it permits any number of alternatives. Even test standards that are not listed in the NBC are permitted to be used if these provide equivalent results (Article 2.5.3.1.).

As noted previously, the NBC references 210 standards produced by various standards writing agencies, so that many requirements that regulate construction are beyond the direct control of code committees. Nevertheless, all such documents are subject to the equivalency requirements specified in section 2.5 as previously described. To ensure primacy of the NBC requirements over those of referenced documents, Article 2.7.2.1. requires that "In the case of conflict between the provisions of this Code and those of a referenced document, the provisions of this Code shall govern". If a reference document does not permit options, therefore, the provisions in Section 2.5 could still apply. (The role of referenced standards will be discussed later).

The alternative design solutions permitted in Section 2.5 should not be considered as merely a well intentioned gesture without practical significance. This section has been actively used by code administrators for many years as a legal basis on which alternative design solutions are judged. It has also been used by CMHC as the basis for accepting new products or systems for use in NHA housing, since it also formed part of the Residential Standards previously used by the Corporation. Down through the years it has undergone numerous changes to increase its effectiveness in permitting new products or systems wherever the NBC is adopted.

Proving adequacy or equivalency, however, is easier said than done, particularly if the performance objectives are not stated in measurable terms, or are only implied through prescriptive requirements. The onus is on the proponent to prove his case. If there is a knowledge gap that prevents this, or if the local official will not or is not empowered to make evaluations, the innovator may indeed be thwarted in any attempt to introduce a new product or system. If there is insufficient knowledge on which to evaluate a particular innovation, there will no doubt be insufficient knowledge on which to establish a realistic performance requirement. The opportunity is there for the proponent to develop his case in any event.

Canadian Experience with Non-Verifiable Performance Requirements: There has been past Canadian experience with the development and application of non-verifiable performance requirements.

In 1965, Part 9, Housing, of the NBC was rewritten in general performance terms (Appendix C). The performance requirements specified that various aspects of houses and apartments be designed and constructed to conform to "good practice". Good practice in turn was deemed to be met if the construction conformed to the example prescriptive requirements in Residential Standards [10]. The latter described construction practices in considerable detail. In effect, Part 9 served as a check list to reference certain requirements in Residential Standards which contained the type of detail considered necessary for design and enforcement purposes. Part 9 was essentially ignored by code users since it was both uninformative and unenforceable. The succeeding edition of the National Building Code (1970) incorporated the detailed requirements into Part 9, and discontinued its reference to Residential Standards. The abandonment of the general performance approach was a direct result of complaints from code users.

The cladding requirements in the 1965 NBC also appeared in the format of non-verifiable performance requirements. Unlike Part 9, however, the buildings to which these requirements applied were generally those that were professionally designed. These requirements, while also referencing Residential Standards for certain practices, were essentially for larger buildings for which the requirements in Residential Standards had little application. The requirements, later became Part 5, "Wind, Water and Vapour Protection", of the NBC. Virtually no comments were received by the ACNBC Secretariat, either from designers or enforcement officials, with regard to this Part of the Code. This was assumed to be due to the fact that the requirements were seldom used for design or enforcement since they provided the designer with little that could be specifically used.

The performance approach in Part 5 has persisted down through the years, (Appendix D). Building officials apparently rely on designers' expertise in such matters in professionally designed buildings. Although Part 5 still references details in Part 9, these are now limited to those appropriate for low-rise construction.

In recognition of the non-specific nature of Part 5, a decision was approved by the Associate

Committee on the National Building Code (ACNBC) to develop a Commentary for this part that would act as an explanatory guide for users to indicate how its provisions can be met. This would, in effect, act as a deemed-to-satisfy document. This Commentary is in the developmental stage and is expected to be completed in a year or so. In the course of its development a number of performance-related issues have been brought to light regarding the requirements in Part 5 and these will have to be addressed in future code editions. There is a possibility that the non-specific nature of this Part will have to change if the construction practices described in the proposed Commentary are to be effective.

2.3 The Increasing Reliance on Reference Standards

The 210 individual standards referenced in the NBC is approximately 10% more than in the previous edition and continues the trend of the code to depend increasingly on other standards to regulate building construction.

As more requirements are removed with each new code edition and replaced with references to other standards, such standards are assuming ever increasing importance in the regulatory function. Increasingly, the NBC is being used as a "directory" to the use of, and an instrument for giving legal status to, these standards. **The performance nature of the code is now very much a matter of the performance nature of its growing legion of referenced standards.**

The design standards for wood, steel, concrete and masonry, which used to form a large portion of Part 4, for example, have now all disappeared from the code, and are replaced with reference to design standards produced by others. Installation requirements for solid fuel appliances which formed a substantial part of Part 6 are now also gone. More recently, requirements for solid fuel space heaters have been removed from Part 9, along with requirements for plastering, flue pipes, glass thickness tables and certain drywall installation requirements. These have been either partially or totally replaced by references to other standards.

This trend is likely to continue as standards writing organizations continue to prepare standards in areas currently covered directly in the NBC. Separate standards, for example, now exist for masonry chimneys, gypsum wallboard installation and roofing installation, and are being prepared for mechanical ventilation of dwelling units. These may be subjects for

future code deletions.

The net result of this transfer of requirements is that the Code tends to become less a stand-alone document, depending increasingly on other sources to flesh out its requirements. While this transfer relieves code committees of the responsibility for maintaining expertise in these fields, there are certain potential disadvantages that should be considered.

The NBC's prime concern is for the health and safety of building occupants, and its requirements are intended to be the minimum necessary to achieve these goals. They are not, or at least should not be, concerned with objectives that go beyond this mandate.

Referenced standards, on the other hand, may not have the same objectives. Such standards may be targeted at other groups such as architects, material purchasers or specification writers who may also have to consider properties that are unrelated to health and safety.

While code committees are aware of this risk and have adopted guide lines for such referenced standards, there may be a temptation to transfer more responsibility to other agencies, particularly if the resources to supply committee support services are difficult to obtain.

With increasing reliance on referenced standards, the Code may become increasingly more difficult to use, particularly for requirements that need field inspection for verification. There is a potential danger that requirements located in other documents may not be as diligently inspected as if they were in the NBC itself.

Like the requirements in the NBC, the requirements in the referenced standards tend to be written more in prescriptive rather than performance terms, and for the same reasons. Prescriptive standards are easier to develop and to interpret without recourse to extensive testing.

In many cases, standards may describe products made from one specific material. In such cases it may make little sense to attempt a performance approach if the effect is to make the standard more difficult to interpret or administer. In most other cases, however, standards tend to be a mixture of performance and prescriptive requirements, much like the NBC.

All standards writing organizations profess to be sympathetic to the concept of performance requirements where these are appropriate. The Canadian Standards Association, one of the most important contributors of reference standards, has in fact stated this in their guidelines to their committees [11]. According to these guidelines "They (standards) should be written wherever possible as performance standards (i.e. in the least restrictive manner possible, consistent with adequate definition of the requirement), and specified in measurable characteristics". It goes on to say, "Each requirement of a standard should be stated unambiguously in wording that is logical, clear, succinct, valid and specific, i.e. the requirement should be verifiable". It may be that similar guidelines should be considered by other codes and standards writing organizations as well.

2.4 Administering the Code

The authority for a municipality to enforce building regulations must first be granted by the provincial government. Without it, municipalities have no legal authority to control how buildings are constructed.

At one time, administrative requirements describing the rights and duties of owners and building officials were contained in a separate part of the NBC. In addition, other administrative provisions relating to the discretionary power of the building official to accept alternative measures were scattered throughout other parts of the Code. In earlier years this was considered appropriate since the NBC was originally designed as a model bylaw, intended for municipal adoption. Provincial governments of that period routinely granted their municipalities the necessary authority to adopt such bylaws. When provincial governments began withdrawing this authority in favour of provincial building regulations it became apparent that the bylaw format was not appropriate. The administrative requirements were removed, and in 1980 the NBC was issued in a non-bylaw format. Since some provinces have not as yet adopted provincial buildings codes, however, the administrative requirements continue to be published for guidance to municipalities but as a separate document [12].

The additional administrative requirements scattered throughout the code giving building officials the power to make discretionary decisions on alternative design solutions were also withdrawn when it was not practical to restate the requirement in technical terms describing the basis for allowing such alternatives. Section 2.5 (described earlier) which outlined the

basis on which equivalencies could be established for any code requirement, was developed as a result of this action. This helped to clarify that the equivalency provisions applied to all code requirements, not just to those that specifically mentioned the building officials' discretionary power. In doing this, the code user was in effect provided with a legal defense against the arbitrary exercise of discretionary power.

Although considered by some as being administrative in nature, the equivalency provisions in Section 2.5 were held to be so essential to the proper administration of the NBC that they were retained as an integral part of it rather than included in the separate document on administration.

When a provincial government adopts the NBC, and does not alter or override these equivalency provisions, the local building official is automatically given the authority to rule on equivalencies. If, the provincial authority excludes this section or overrides it in some way, then the local building official may not be allowed to exercise this authority. This could result in users perceiving the building code as being restrictive if such decisions are not within his legal power.

It is of interest to note that in adopting the Ontario Building Code, this authority for accepting equivalencies was not granted to municipalities. This was a cause for concern especially in the initial use of the Ontario code. Revisions to the Ontario Building Code Act introduced into the Legislature towards the latter part of 1989, however, contain an amendment allowing municipal chief building officials "the power to permit the use of equivalent materials, techniques or systems to those permitted in the Building Code, provided the level of safety and performance is not reduced" [13]. The revisions will also "streamline the process for approving innovative building products and permit the Minister to authorize the use of innovative materials, products, systems and services approved by the Canadian Construction Materials Centre".

Administrative Competence: A building official unfamiliar with the requirements to be enforced or who lacks an appreciation of their objectives cannot be expected to be an effective code administrator without considerable assistance from others.

Periodic revisions to close loopholes or to accommodate changing societal needs, or for other reasons, tend to make building codes increasingly complex and place ever growing demands

on code users.

In larger municipalities, code administrators may be able to specialize to make the task more manageable. For example, plans examiners or field inspectors may specialize in smaller buildings such as houses, while others may specialize in fire safety, HVAC or structural requirements for larger buildings.

In smaller municipalities, however, the volume of building may not allow this. Unless the building official is exceptionally well trained, he may have to rely on the seal of professional designers as proof of code compliance or on other sources he chooses to trust. In less complicated buildings such as houses where professional designers may not be involved, a reasonable competence level is easier to attain.

As would be expected, therefore, there is a wide range of technical competence levels in code administration. Simply because a municipality has adopted a building code, or is required to conform to a provincial code, is no guarantee that buildings will in fact be constructed in conformance with it. As with any law, it is generally much easier to write legislation than to enforce it.

Equally important to a knowledge of the requirements, however, is an appreciation of their intent and objectives. Without this appreciation, the enforcing official has little choice but to take a narrow literal meaning for each requirement. This may also lead to a reluctance to accept equivalencies even where the official has this authority. Poorly trained officials, particularly those unprotected from personal liability claims, can therefore be expected to act conservatively in assessing alternatives. To the designer or owner, this attitude may well be interpreted as being due to the restrictive nature of building codes rather than the fault of the building official. Whereas a well informed administrator with a positive attitude towards innovation can be of significant assistance to code users; a poorly trained official can discourage innovation, ignoring provisions that permit alternatives.

Educational Programs for Code Administrators: Provincial, and to some extent, federal agencies have various on-going programs aimed at improving the building officials understanding and applications of code requirements. Several provinces have developed well structured educational programs leading to eventual accreditation of building officials (as noted in Appendix A). These include technical and administrative courses in addition to

those relating to the building code itself. In other provinces, however, the formal training or upgrading programs have either been neglected entirely, or been left in the hands of other agencies such as building officials' organizations.

Accreditation programs may be graduated into a number of proficiency levels, depending on the necessary credit courses. A building official, for example, may have had only sufficient training to enforce requirements for housing and small buildings. Additional training may qualify the official to enforce requirements for larger more complicated buildings (such as those within the scope of Part 3 of the NBC)

It may be of interest to note that a suggestion was recently put forward in a report prepared for NRC's Canadian Construction Research Board (CCRB) [14] for a Building Regulatory Congress to be organized to bring together the principal interests in code administrations including municipal, provincial and federal agencies involved with building regulations as well as representatives of the construction industry. The purpose of such a congress would be "to provide a forum for the sharing of knowledge, to put forward new ideas, to identify problems as viewed by the building construction industry and the administrative and enforcement agencies at the national, provincial and municipal levels". If this congress is held, it would appear to be an appropriate forum for an interprovincial discussion on the training and qualifications needed for proper code administration as well.

Other Technical Support Services: As is the case with the training of building officials, there is a vast difference in the level of technical support services provided by different provincial ministries to assist local building officials (Appendix A). A number of provinces have professional support staff competently trained to provide back-up support for local officials in giving code interpretations and in providing an evaluations service. Support services may also include the dissemination of information through lectures, workshops, seminars and the publication of regular news letters, information bulletins and educational aids. In some provinces, however, this back-up support is almost non-existent.

Federal technical assistance to code users is provided through NRC's code support staff. These activities include an inquiry answering service, participation in seminars and workshops, and providing lecturers for buildings officials training courses. Other activities include the periodic publication of a newsletter to keep users informed about code related matters, and the publication of explanatory material in the form of commentaries to further clarify the aims and objectives of code requirements. All of these activities improve the

knowledge of code users in the technical requirements of the NBC and in one way or another assist in the proper application of code requirements.

Cost of Administration: The complexity of building codes make them increasingly difficult to administer effectively, particularly when the 210 standards referenced therein are taken into account. It is inevitable, therefore, that this aspect of the NBC will have to be addressed in future code discussions.

Not only is the administering complexity a growing concern, but the cost and efficiency of administration will also have to be addressed.

The direct cost of building code administration in the 4000 or so Canadian municipalities is not known, although it would appear to be substantial. To this must be added the indirect costs of delays in construction due to the enforcement process, as well as any construction costs due to ineffective code requirements.

A regulatory reform initiative sponsored by Canada Mortgage and Housing Corporation has identified the cost of inspections as one of the issues to be addressed in building regulations. The reform initiative is being carried out under the guidance of the Federation of Canadian Municipalities, the Canadian Home Builders Association and the Canadian Housing and Renewal Association.[15]

All provinces in fact are either actively pursuing or at least studying ways for making the administrative process for building regulations more efficient such as by combining the various inspection services (ie. building, electrical, plumbing, gas, elevator, boiler and pressure vessels), privatization of inspection services, contractor licensing, and providing unified access to the entire building regulatory process [14].

The approach initiated by the city of Vancouver is worthy of examination. In 1980 it decided to transfer a larger portion of responsibility for code compliance to the professional sector. Architects and engineers who successfully completed appropriate code related courses were designated by the city as being capable of certifying their own designs for code compliance, and carrying out their own inspection. At present about 60 professionals are so registered. A similar system is currently being reviewed for the province of Ontario.

Foreign countries are also concerned about the cost of administration of building regulations. This is discussed later under the subject of "Building Regulations in Other Countries".

2.5 Evaluation Machinery: The processing of innovations

Few complex buildings can be constructed without the need for evaluating alternative design solutions. Designers by their nature are creative, and are not inclined to use a building code purely as a recipe book. They constantly innovate, and indeed, this is expected by their clients. Alternative design solutions, therefore, must be evaluated to assess whether or not their solutions maintain the implied levels of health and safety that building codes require. Structural interpretations of alternatives are facilitated by generally accepted design procedures and loading conditions. Interpretations affecting health and fire safety, however, are much more difficult because the state of the art of design in these fields is not as scientifically well based. Evaluation of alternative designs or "trade-offs" therefore often require astute judgement of experienced evaluators. These evaluations are part of the day to day use of code requirements, and are for the most part made at the local level. (In most provinces, provincial authorities provide assistance when requested by local administrators).

Since these decisions affect generally only the building under consideration, the consequences of the decision are usually limited. When a proponent wishes to market a new product or system, however, and obtains prior permission to use it in any building, the effect of such innovation can have more wide ranging consequences. Considerable care must be exercised to make sure that the innovation will not only perform adequately its intended function, but will not itself create a new hazard.

New products are usually evaluated either against those they are intended to replace, or less commonly, against accepted performance criteria for their particular end uses.

The degree of difficulty in making such evaluations, needless to say, varies widely. Simple products made from materials with known characteristics, may be dealt with adequately by the exercise of common sense and do not require extraordinary knowledge of materials behaviour. Where materials or systems are used for which the long term performance or ageing characteristics are unknown, or which may release chemicals that create a potential health hazard, however, evaluation may become enormously complicated and even tax the wisdom of experts familiar with the properties of materials.

Normally, it is not economical for a municipality to maintain the level of expertise necessary to carry out this function on a formal basis. Such evaluations are therefore usually undertaken at the provincial or federal level. Ontario and Alberta provide such a service. In other provinces, however, such evaluations are made on a more informal basis by local administrators .

The Pioneering Role of the CMHC Acceptance Program: Until 1988, CMHC provided an evaluation service for products used in buildings constructed under the National Housing Act. This was accepted by many as a defacto national approval system. Since it was the policy of CMHC to use the requirements of the National Building Code as the basis for its health and safety requirements, CMHC was in effect also evaluating materials for use under the National Building Code.

In many ways this was a remarkable system and made significant contributions to the development of building technology, not only for NHA housing, but to the entire Canadian building industry. This was particularly true in its earlier years when relatively few product standards existed for the then new products reaching the market place.

It operated with little bureaucracy, and was assisted technically by NRC, the Forest Products Laboratory (now Forintek Canada Corp.) and other government agencies. Acceptance of a product or system resulted in its being listed by CMHC along with its conditions of use. Although in its earlier years CMHC did not operate any formal program for periodic reevaluation for on-going performance, the large CMHC inspection staff throughout the country ensured an effective feed-back system to identify any significant problems that developed.

The CMHC evaluation program not only instigated a number of significant research programs at NRC and Forintek, but was responsible for introducing a substantial number of national standards that served to consolidate much of the knowledge gained from the evaluations.

The evaluation and listing service operated by the Corporation (originally provided free) also proved to be a valuable marketing tool for proponents of new products. Being included on the list of accepted products was therefore one of the first objectives sought, both for innovators and conventional product manufacturers.

While the listing had little relevance in a legal sense beyond NHA authority, it was nevertheless widely respected by provincial and municipal building authorities and was commonly used by them. It also had two important limitations. CMHC's interest was solely in the field of housing, and did not necessarily apply to buildings of other occupancies. In addition, considerations in evaluating new products went beyond the normal building code limits of health and safety since the Corporation's primary objectives were to improve the quality and accessibility of housing, and to protect their financial interests in the mortgages they guaranteed.

Progress Towards a National Evaluation Service: As the use of the NBC became more widespread, therefore, various sectors of the construction industry recommended that the Associate Committee on the NBC establish a national evaluation service for building code purposes. A three year study completed in 1973 led to a recommendation that NRC establish such a service. This was rejected at that time, on the grounds that it was not an appropriate NRC activity.

As more provinces adopted provincial codes based on the NBC, the demand for a central evaluation service was again raised. A new ACNBC task force was asked to investigate the possibility of agencies outside of NRC taking on this responsibility. It concluded that if NRC could not accept this role, the Standards Council of Canada be asked to do so. This was declined by the SCC.

Meanwhile, concern about the legal ramifications of the CMHC evaluation program (following the furor over the use of urea formaldehyde foam insulation) caused CMHC to convert its program to a system modelled after the evaluation services provided by other model code agencies. In 1981, the corporation began issuing evaluation reports for new products but did not "accept" them as they did formerly. The more formal procedures, adopted as a temporary measure, were intended to be replaced eventually by an independent agency. Armed with the results of a survey indicating broad industry and regulatory support for a national evaluation service (86% in favour) [16], CMHC again negotiated with NRC to assume the responsibility of this service. This was eventually agreed to, and became operational in July 1988 as the Canadian's Construction Materials Centre (CCMC), an adjunct to NRC's Institute for Research in Construction.

To some extent, the service provided by CCMC is a continuation of the service provided by

CMHC. The core staff is the same, and the products formerly evaluated by the Corporation continue to be recognized. CCMC, however, will now operate under the aegis of a new NRC Advisory Committee on Construction Materials Evaluation (similar in function to the NRC Associate Committees responsible for the National Building Code and National Fire Code).

The Role of CCMC: The Canadian Construction Materials Centre describes its role as follows:

"to help the construction industry to meet the challenge of competition in the market place by offering a national evaluation service for innovative materials, products, systems or services. In the evaluation process, the suitability for use of a product is assessed. If it proves to be suitable, then an Evaluation Report or an Evaluation Listing is issued stating that the product meets the intent of the requirements of national or provincial building codes, the National Master Specification, construction product standards, or other performance criteria requested by the manufacturer" [17].

An "evaluation listing" is provided if there is a published standard to which the product is manufactured. An "evaluation report" is provided if there is no such standard.

The new evaluation service, therefore, is intended to have a somewhat greater scope than the CMHC acceptance service that spawned it. It may also be noted that the listing service provided by CCMC applies to all buildings types, not just housing. (A report of current CCMC activities is provided in Appendix E, based on its most recent report to the ACNBC).

The first of two volumes of the current "evaluation listings" published under a new and simplified format has recently been published [18] and the second is scheduled to be published later.

A recent study commissioned by CCMC investigated the feasibility of developing a cross-reference index of product evaluation programs used in Britain, France, United States, New Zealand, Australia and Canada that could be used to provide information on products to the building industry [19]. The index is also intended to be used by CCMC to reference information from these countries when developing CCMC "Technical Guides" and Evaluation Reports. It is also expected to market the index in other countries.

The Future Role of CCMC: It is too early to judge the potential impact that the CCMC service will have on the construction industry. This will depend on the extent to which regulatory, design and other building sector interests make use of the system and the response of the system to user needs.

Memoranda of Agreements are being circulated to provincial and territorial authorities with the intention of committing these agencies to the use of this service, thereby reducing the possibility of duplication. Early signs indicate a growing support for the new service.

Although CMHC has provided the core staff and funding for the start-up of the service, it is operated on a fee-for-service basis with the expectation of future contributions from provincial governments as current CMHC contributions decline in future years. The degree of provincial support, therefore, may well play a major role in the future success or failure of this enterprise.

Other Evaluation Agencies: Other Canadian agencies also maintain evaluation and listing activities, normally in support of a certification and labelling service. These were discussed earlier in Chapter 2. A directory of Construction Products Standards and Evaluation Programs has recently been published by CCMC showing the standards used for listing or certifying products in Canada [16].

The Need for Evaluations: That there is a need for an evaluation and listing service, there can be little doubt. Such a service provides an important component in the regulation of buildings that cannot be addressed through building codes alone, regardless of whether they are performance or prescriptive oriented. All three U. S. model code agencies maintain such systems as do many other foreign countries, as a component in the building regulating process. Such evaluation programs form an essential bridge between building codes (which are developed mainly around generic materials), and proprietary or innovative materials that may not have been conceived at the time of the code requirements when written.

Where prescriptive standards are used to evaluate products by comparison, many essential characteristics are left unstated because the nature of the product is known. When new products are proposed for replacement, therefore, a thorough knowledge of building materials is required as well as an astute appreciation of the objectives of building regulations. A judgemental process forms an essential component in areas that cannot be satisfactorily

quantified. A positively motivated evaluation system, therefore, can act as a valuable lubricant to the innovation process, while still protecting the public interest in maintaining health and safety standards.

Evaluators Must Think in Performance Terms: The process to evaluation, is by its very nature performance oriented. Evaluations of new products must constantly seek to determine the qualities needed to provide acceptable performance. Indeed, without this approach, there is little basis for assessing a product for which there is no standard. The thinking process must not only analyze and determine the performance objective, it must also identify knowledge gaps that must be filled through research and testing. This process of thinking in performance terms to evaluate product adequacy, it may be noted, is essentially the same as is needed for developing workable performance requirements in building codes. If the evaluation of a product is limited because of a lack of knowledge of product characteristics, so also is limited the extent to which its performance requirements can be written in measurable terms. The knowledge gap that prevents proper product evaluation and restricts the growth of performance based requirements also restricts further product development. In other words, a product cannot be developed to "replace" an existing product, if its relevant long term and short term characteristics are not known, or if the specific functions or performance objectives are not clearly defined in measurable terms.

Influence of Product Evaluation on Building Codes and Standards: Although in past years the evaluation process has contributed measurably to the establishment of many product standards; there has been surprisingly little direct influence on building code requirements. This may be due partly to the fact that CMHC evaluations were generally for products which can be better described in standards rather than in building codes. It may also be due in part to the fact that evaluation and code functions were under different agencies with quite separate and distinct responsibilities. In future, however, with both functions under the same NRC umbrella, an excellent opportunity would seem to present itself for constructive impact of the evaluation program on the code making process.

The stated intention of providing close liaison between CCMC and the code support staff, is an encouraging sign that the two operations will in future complement the efforts of each other. This will be of particular significance if a decision is made at some future date to accelerate the progress towards performance building codes.

A number of CCMC Evaluation Guides already exist for various products, and many of these could eventually find their way into codes or standards as the basis for performance requirements. This could lead to formalizing in quantitative terms performance requirements for certain building components as an alternative to existing prescriptive requirements.

2.6 How Much Restriction of Innovation?

If it is given that building production has such societal impact that some public regulation of the process is necessary, then it follows that innovation cannot move freely and instantly into the market. Its introduction must be restricted, but not unduly so: Ideally, it will be restricted only long enough to allow evaluation of performance. "Unduly restricted" means that such evaluation is either unfair, or the process is simply too slow

Case Histories of Past Innovations: From preceding discussions of the major components of the regulatory process (code requirements, administration and evaluation) it was noted that restrictions to innovation may arise from any one of these.

If current problems exist that unduly restrict such innovations, it is essential that their seriousness and extent be identified before specific remedies can be discussed. Is there in fact a significant problem? Is the problem due to the prescriptive nature of the code?

One way to assess the influence of the major regulatory components on innovations is to look back over a number of years to assess the role that they played with the earlier introduction of innovations.

The years following the end of World War II ushered in a virtual flood of new products and building systems: Literally hundreds of new systems were brought forward incorporating an array of building materials assembled in almost every conceivable manner. Many of these were submitted for use in NHA housing and hundreds were accepted after a relatively short evaluation process.

Of the hundreds of products and systems that were eventually accepted, many did not make it to the prototype stage, either through lack of financing or lack of purchaser interest. Many others gained a fleeting mention in trade magazines or in the local press before disappearing from the scene. In short, many innovations were not able to compete with existing products

or systems because of costs or marketability. A few failed in field performance, perhaps indicating that the evaluation process was not unduly restrictive.

Many others were successful, and they or their derivatives are embodied in today's "traditional" housing and its governing codes and standards. Some of the innovations rooted in the fertile postwar decades include, not in any particular order: residential roof and floor trusses; preserved wood basements; factory made chimneys and fireplaces; waferboard, strandboard and particleboard subflooring and sheathing; polyethylene vapour barriers; insulating sheathings; plastic sheathing felts; prefinished hardboard, aluminum and vinyl sidings and soffits; foamed plastic, cellulose and friction-fit glass fibre insulation; plastic bathroom units; plastic DWV and potable water piping, footing drain tile, window sash, trim, flooring, carpeting; insulated metal doors; insulating glass; precast concrete steps; single-ply membrane roofing systems; adjustable basement columns; residential heat pumps; spiral and helically threaded nails, and drywall screws. The list goes on.

Most products gained initial national acceptance through the CMHC acceptance system then in effect, and not as a result of code changes. Such acceptances were commonly recognized by most code jurisdictions since they carried the implication that the product also met the requirements of the NBC, which was also in general use. Even though the acceptance was intended only for NHA houses, the system was effectively recognized as a national evaluation system.

When roof trusses were initially introduced into Canadian housing, they first gained acceptance through the CMHC acceptance program. Trusses were in fact in use for several years before rational performance requirements on which such acceptances were granted were introduced into the Residential Standards and later into the NBC: This is discussed in more detail later.

Preserved wood basements were also initially accepted by CMHC on the same basis. Although they were not prohibited by the NBC, no acceptable basis was available by which a local authority could control their construction. The CMHC terms for acceptance provided many jurisdictions with the guidelines needed to permit their use. Later when CSA developed a formal standard for preserved wood foundations this was adopted by reference by the NBC, but this was several years after CMHC acceptance.

The same general pattern is also true for most of the post war innovations previously noted. The initial CMHC acceptance not only provided local authorities with reasonable conditions for allowing the use of such products, but provided the proponent with a valuable marketing tool as well. Acceptance by a government agency to many Canadians is tantamount to a seal of approval, so that acceptance by CMHC was commonly solicited by proponents even when this was not a requirement.

It may be seen, therefore, that in the vast majority of cases the CMHC acceptance program played a much more direct role in facilitating innovations than did the NBC. Indeed, without the CMHC acceptance program the restricting effect of the NBC on such innovations may well have been quite different, particularly in the light of the limited technical capabilities of local enforcement officials in the immediate postwar period. It is also worth noting that while the NBC played a relatively minor role in influencing the introduction of innovations, it did not prohibit their use, once their adequacy or equivalency was established.

It should not be surprising that most innovations have been facilitated as a result of a successful evaluation program and not as a direct result of code influence. Prescriptive requirements, whether in codes or in standards are generally written for generic products, and are not written with unique or innovative products in mind. As will be discussed later, in many cases it is simply not practical to develop measurable performance requirements for building products without knowing the material from which the product is to be made. Innovations, however, are generally introduced into the market as unique proprietary products for which there may be no relevant standard. These products, therefore, have to be individually evaluated.

The evaluation component, therefore, appears to be the key ingredient in the regulatory process facilitating innovations. The manner in which this function is carried out can have an effect on innovations to a far greater degree than the manner in which a code requirement is expressed, particularly in the light of the equivalency requirements in Section 2.5 of the NBC.

Current Cases: How Much Restriction of Innovation Now? : While it is useful to review how past innovations have been influenced by the principal components in the regulatory process, it is necessary to focus on current influences. In particular, it was considered to be essential to determine : (1) the extent to which innovations are currently being restricted

from the marketplace, and (2) to determine the particular sector of the regulatory process responsible for the perceived restriction.

Letters were therefore sent to a number of major building materials manufacturers and associations representing various building industry interests, inviting them to submit specific cases where undue restrictions were perceived. The house building industry was contacted through their association (CHBA) who in turn contacted their regional representatives. NRC's Canadian Construction Research Board was also contacted and through their office contact was made with their regional chapters. Follow-up letters were sent when replies were not received.

Very few written responses were elicited. This in itself was not surprising: some years ago, on first considering the need for an evaluation service, the ACNBC drew no response when it asked industry for examples of restriction of products from the marketplace. Such apparent lack of interest might imply that industry is either satisfied that the process is not unduly restrictive; or, considers that there is no point in protesting.

Although the responses were few (including both written and verbal responses) one pattern was clear: Manufacturers of well-established products and assemblies, particularly the traditional, inorganic materials, profess satisfaction with the code process more or less as it stands; producers of relatively new products (plastics), point to what they consider arbitrary and needless restrictions. The former generally dominate the market, while the latter, who are now competing for this market, think their progress is being opposed with groundless and costly delays. The latter respondents also suggest that Code committees, with representatives from both sides, are divided accordingly in their consideration of the old vs. the new. The following examples, quoted from letters, are considered useful in delineating the part of the regulatory process in which the restriction was caused. Each example or claim is followed by an explanation and a discussion without attempting to verify or evaluate the merits of the case.

1. Combustible Cladding on Non-Combustible Buildings

"After an extensive (costly) NRC/Industry test program on the fire performance of combustible cladding systems, the NBC imposed an arbitrary 3-6 storey height limit on such systems before approving the test procedure. There was no technical basis for this restriction

and as a consequence the industry has no direction on what data is needed to remove this restriction."

Comments:

Prior to the 1990 Code, non-combustible cladding was required for all buildings required to be of non-combustible construction, regardless of building height. The 1990 NBC relaxed this to permit up to 3 and 6 storey buildings to have combustible cladding, depending on whether or not they are sprinklered. Such cladding had to meet certain test performance criteria. The proponent apparently believes the criteria should apply to buildings taller than 3 and 6 storey. (A subsequent letter has listed a number of cases in other countries where such combustible cladding is accepted and is in use on higher buildings).

It is not known on what basis the proponent was led to assume that the performance requirement was to apply to all buildings, or on what basis the new relaxation was limited to 3 and 6 storey buildings. Who is right and who is wrong is not really relevant in determining whether or not the perceived undue restriction was due to a lack of performance requirements.

In this case, the alleged undue restriction appears to be due more to the end use performance level required rather than to whether or not the requirement is prescriptive or performance in nature. The proponent obviously believes that the requirement for non-combustible cladding (which can be considered as a type of performance requirement) is not justified. If the code committee believes that it does not have sufficient information to lower the performance level (rightly or wrongly) then it is the knowledge gap that is causing the alleged undue restriction, and not the prescriptive nature of the requirement.

2. Building Paper Over Foamed Plastic Insulation

"Requirement for building paper on foam plastic insulation: there are no performance criteria."

Comment:

The assumed purpose for sheathing paper is to act as a second line of defence in preventing the entry of rain and wind into the wall structure. Its use originated many

years ago, primarily to reduce air leakage into houses which at that time were uninsulated and clad with lumber sheathing on the outside and wood lath and plaster inside.

While a case may be made for performance requirements to set levels for wind and rain resistance, this may not really be necessary to resolve the problem.

For example, it has long been questioned whether the sheathing paper serves any real purpose if the sheathing is of a type that acts as an effective air barrier, such as plywood, fibreboard or waferboard. Rain penetration may not be a significant concern since it has been shown from experience that sheathing paper is not needed under roof shingles which presents a more serious rain exposure condition.

In this case, therefore, while a verifiable performance requirement may have overcome the restriction, an alternative solution would be to simply rationalize the requirement.

3. Thermal Protection for Foamed Plastics in High Buildings

"Thermal Barrier change: The 1985 code arbitrarily imposed a requirement for 2 layers of 5/8 " type "X" gypsum protection over foam plastic insulations. There was no logic to this decision and it took 5 years for industry to remove the change - at great expense and loss of business."

Comment:

The low thermal inertia of foamed plastic insulation causes a rapid temperature rise where room fires occur, leading to a very short flashover period. To increase the flashover time to give occupants more time to escape, thermal protection is required over the foamed plastic. This protection has varied since the requirement was introduced in 1977, but in the last edition of the NBC, a 45 minute protection was required for high buildings and 10 minutes for other non-combustible buildings. The 45 minute protection could be achieved by 2 layers of 5/8 inch type x gypsum board, and the 10 minute rating by 1/2 inch of regular gypsum board. In 1990, the requirement was changed to permit 10 minute protection in all cases.

In this case there was (and is) a performance requirement to evaluate the protection for the specified time. The 1990 reduction for the requirement indicates that the code

committee believed the previous performance requirement to be excessive.

The earlier restriction was due to the level of performance required, and not to the lack of a performance type of requirement.

4. Cementitious Plastic Coating for Foamed Plastics

"Initial difficulty in gaining CMHC approval of a cementitious plastic coating used on a cellular plastic insulation in basement/grade applications. Restricted to 4'0" above grade, though poorer quality stucco is generally accepted. No clear performance tests available other than long-term history."

Comment:

The NBC provides prescriptive requirements for portland cement stucco based on traditional practices.

The requirements in the NBC for portland cement type stucco may or may not be relevant to the product in question. The requirements in the NBC were established in recognition of known properties which presumably will be different for the product in question.

It would have been helpful if verifiable performance characteristics existed for this product. It would appear to be unlikely, however, that meaningful performance criteria could be developed without knowing the physical and chemical composition of the product. Since such products are proprietary in nature, the development of generalized performance criteria would seem to be unlikely.

This perceived undue restriction, therefore, seems to rest with the product evaluation system rather than the NBC. Again, it is not the purpose of this review to judge if the proponent has or has not a valid complaint, but only to indicate in which sector the perceived problem had occurred.

5. Lack of Performance Requirements for Air Barriers

"Air barriers have been "required" by the code since 1985. Even in the 1990 NBC, there are no explicit performance criteria. This guesswork confuses the marketplace."

Comment:

Part of the 1990 NBC states that "air barrier protection shall possess the characteristics to provide an effective barrier to air exfiltration under different air pressure due to stack effect, mechanical systems or wind." It goes on to describe other requirements if polyethylene film or panel type material is used.

This would appear to be an example of a non-verifiable performance requirement for which deemed-to-satisfy solutions are given.

Presumably the proponent would prefer to change the nature of the requirement from a non-verifiable to a verifiable type. This would be preferable if there were sufficient information to do so in a realistic manner. Without such knowledge the requirements may well end up as being too restrictive or even meaningless.

6. Undue Influence of Lobbyists

"Lobbyists from single suppliers can greatly influence the development of the code - as evidenced by (a certain company's) apparent success at reducing (a provincial) code requirement for thermal insulation from R-19 to R-18.5 to favour their product."

Comment:

This individual complaint affects a particular provincial code and not, in this case, the NBC. (It is also a subject area not covered by the NBC.) While the complaint may or may not be valid, it does raise a subject that should be addressed.

No doubt the art of lobbying is practised in committees where vested interests are represented. These biases are generally recognized at committee meetings and do not detract from the value of the committee work, provided the system is kept fair by appropriate checks and balances.

The ACNBC operates at arm's length from government departments. It also operates under a set of rules and procedures that ensure a broad representation of interests, so that no one group can dominate decision making. At the provincial level, where a code is finally applied, vested interests are part of the electorate with full right to bring their concerns to the table. Presumably, therefore, lobbying is more likely to occur at this

level by those who desire change to help their particular interest.

7. Lack of Recognition of Foreign Tests

"Fire regulatory authorities (ULC) take a lot of convincing to accept test data developed in the USA by ULI or FM. It took many months for us to gain acceptance of one of our recent ULI listings by the ULC. Delays in product introduction can be a major deterrent to industry to introduce innovative systems and new technology into Canada."

Comment:

While many ULC and ULI test standards are similar, they are seldom identical. In the past this has led to certain products receiving significantly different ratings, depending on where they were tested. In other cases, however, the differences between standards are insignificant and test results are practically the same. The differences in some cases are product dependent, being similar from some and widely different for others.

Fire tests are relatively expensive and are avoided unless absolutely necessary. The frustrations caused by the lack of a common standard can be appreciated. This problem occurs not only with fire standards. It can occur in other areas as well and with other countries than the USA.

This example, while not related to prescriptive requirements, illustrates a relatively common complaint voiced by those wishing to have products originating elsewhere accepted for Canadian use. It also illustrates the need to harmonize test standards on an international basis.

Again, this problem is more related to the evaluation process than to the NBC.

8. Insulating Wall Sheathing

"(A brand-name insulation) was applied to an addition to ----- house in -----, approximately 10 years ago. The building inspector, realizing that a glass fibre insulative sheathing board was not listed in the building code, applied a stop work order on the site. The stop work order was enforced for 3 months. It was lifted after (the manufacturer) guaranteed in writing, that they would bear the total responsibility for any structural damage

occurring as a result of using the brand-name insulation."

Comment:

In this case, the cause of restriction appears to be in the code administration rather than in the code itself. Neither the NBC nor the provincial code in question prohibited insulating sheathing during this period. In fact the codes did not and does not require any sheathing in most such cases. At that time, however, local officials were restricted in making discretionary decisions and this could have been a factor in the building officials' attitude.

9. Fire Resisting Gypsum Wallboard

"(Company name) was attempting to import and apply at the ---- project a (trade name) product providing a one hour fire rated wall, with an STC of 48, using 1/2 " type "X" gypsum drywall as opposed to 5/8". Since the architectural drawings originated in the United States, UL wall construction designations were specified. The wall designation, UL---- contains (a trade name product), with 1/2" type "X" gypsum drywall. This designation was proposed as a substitute to the specified designation UL----, which uses 5/8" type "X" gypsum drywall. The only ULC designation referenced was ULC---- consisting of 5/8" type "X" gypsum drywall and no cavity insulation. The concern on this project was that the building inspector would unlikely approve the substitution, as the Canadian authorities do not recognize the UL designations. The owner was willing to risk a stop work order rather than consult the building inspector for prior approval."

Comment:

The code specifies minimum fire and sound restrictions in performance terms. The ULC fire resistance rating is generally accepted as a deemed-to-satisfy solution. The difficulty in this case appears to be in the administration sector, rather than in the building code itself or in its performance or prescriptive nature.

The owner apparently made a product substitution without informing the inspector, on the assumption that it might not be approved. The commentator raised the possibility that this could have led to failure had the substitute product been inferior.

Assuming the building official had a reputation for not permitting substitutes, this is

understandable since at that time the provincial legislature did not give this discretionary power to building officials. While similar in some ways to example No. 7, there is a difference in that the evaluator was not the one who made the decision.

Summary of Complaints: Of the nine specific complaints, two were considered to be related to the evaluation process and two to the administration process rather than to the NBC. Surprisingly, three of the four complaints that did relate to the NBC involved requirements that could be considered as performance oriented. In two cases a verifiable performance requirement could have been helpful, but in one of these, the problem may also have been resolved by rationalization of existing prescriptive requirements. In one case the problem appeared to be political, and not related to the type of code.

Additional Code restrictions: While building codes themselves may play a secondary role in facilitating most innovations, this does not mean that they do not exercise a substantial influence on the types of materials or systems that can or cannot be used. The requirements for residential smoke alarms, or prohibiting the use of ordinary glass in certain door locations, have directly affected the use of these products in most new houses ever since the requirements were introduced. The prohibition of loose fill insulation in stud spaces in new construction, or the banning of asbestos fibres in air handling systems, are other examples of code intervention directly affecting product use.

Probably the most significant intervention, however, is the requirement for noncombustible construction where a building exceeds a certain size. This effectively excludes the use of wood structural members in larger buildings as well as other combustible secondary components (unless these are specifically listed as being permitted).

In summary, then, while restrictions to innovations can arise from any of the components that make up the regulatory process, the most important one seems to be the evaluation process for new materials and systems. If a competent and accessible evaluation service is available at the provincial or national level, and there is a commitment to use such a service, then the need for such expertise at the municipal level disappears. The authority to rule on equivalencies or trade-offs that do not involve unique products is still needed, however, to avoid unnecessary delays over trivial matters.

Code requirements also play a role in the process of evaluation where they are used to

establish minimum performance levels. Unless evaluators can establish performance levels on some other basis, unrealistic prescriptive or performance requirements may well lead to unrealistic evaluation decisions.

3. SOME ADVANCES TOWARD PERFORMANCE-BASED BUILDING REGULATION

Summary:

If verifiable performance requirements are based on the performance level of established products rather than on knowledge of required properties, they can be as restrictive as prescriptive requirements. Developing knowledge based performance requirements, on the other hand, is time consuming and expensive. These are usually market driven to fill a commercial need.

The NBC is more performance oriented than many appreciate. Structural design requirements are performance based and apply to all buildings including those in Part 9. The so-called prescriptive structural requirements in Part 9 are, in effect, deemed-to-satisfy solutions that complement the structural design requirements.

Many products are accepted in spite of some properties, and because of others, including cost. Performance requirements are therefore difficult to prepare in the abstract without knowing the constituent materials. Many properties, including aging and health related ones are difficult to define unless constituent materials are known.

Interrelated systems such as those for fire safety are difficult to express in verifiable performance terms. Current fire safety requirements are based largely on random experiences and past practices with relatively little scientific input.

Computer modelling systems are being developed to systematically evaluate fire safety systems with one another. Others provide an evaluation framework to assess all code requirements. Many knowledge gaps remain, however, making comprehensive systems dependent on expert opinions.

Standards referenced in the NBC are a mixture of performance and prescriptive rules. Progress towards performance requirements is slow, and, like those in the NBC, generally market driven.

Although the process of defining performance objectives can be difficult, the process is considered to be worthwhile to assist both designers and building officials to have a better understanding of the code in order to properly evaluate alternative design solutions.

3.1 The Problem of Establishing Useful Performance Requirements

Performance requirements have to be expressed in measurable terms to be useful. In some instances, this can be done on the basis of available knowledge where the objective is well defined and test methods exist to verify the stated level of performance. Where this is

possible, the requirement is enforceable since it can be accurately interpreted by both designers and enforcement officials. While it may still be argued that a requirement that prescribes a specific level of performance is partly prescriptive, most would consider such requirements to be in the performance type category as long as they allow designers freedom of choice in meeting the stated levels.

It should not be taken for granted, however, that all performance requirements, well stated or not, are necessarily realistic. This depends on the state of knowledge in the area being regulated, and the basis on which the performance levels were determined. It is easy, for example, to establish performance requirements in the face of insufficient data by being conservative. While these may permit a variety of design solutions, all will entail unnecessary building costs. Similarly, fixing the level of performance requirements to that of established materials or systems can also entail or maintain excessive costs.

Often, however, knowledge simply does not exist to permit the establishment of realistic or definable levels, in purely performance terms. The data on which such levels are determined have to be generated through additional research if indeed they can be generated at all. In the past, the tendency has been to undertake such research only when the demands of the market place justifies it, i.e., when innovations are envisaged that may capture old markets or open new markets. The level of knowledge available for the expression of performance criteria is not greater, or ahead of, the level available to design innovations unless such knowledge is generated by the proponent.

Establishing Performance Levels by Comparison: One approach in establishing performance levels has been to measure the appropriate characteristics of a material or component that has been known to provide satisfactory performance, and to use this as a benchmark for evaluating new products. If the element has developed to its current state through an evolutionary process of trial and error, the chances are reasonably good that the measured characteristics will provide a reasonable level of performance, at least for similar materials or components. Examples exist in the National Building Code where this has indeed happened.

When residential wood roof trusses were introduced in the 1950's, for example, their structural adequacy was first predicated on the basis of estimated snow loads and allowable wood stresses. These design requirements were, in effect, verifiable performance

requirements in that the performance level was specified in quantitative terms and the designer was given a choice in how this could be achieved, provided specified wood stresses were not exceeded. This approach, however, led to designs that proved to be several times stronger than conventional joist and rafter framing which had evolved through trial and error over many years. It was observed that roof trusses designed by conventional engineering used more lumber and were more expensive than traditional joist and rafter framing, even though the former are intrinsically more efficient. The introduction of roof trusses was therefore seriously inhibited initially, not because of prescriptive requirements, but rather, due to the conservative nature of existing performance requirements which traditional prescriptive roofs had never had to meet.

Since traditional roof framing had a long history of satisfactory performance, the conclusion was reached that the existing "performance" requirements were indeed unreasonably conservative. After a long and expensive testing program to evaluate both traditional and trussed roof strengths, new performance requirements were developed using the strength of traditional construction as a yardstick against which to measure performance levels for roof trusses [20]. In effect, the traditional roofs showed that snow loads were not as high as supposed; they have acted as load gauges, ready to fail if the postulated snow loads ever occurred. (This testing program, incidentally was a direct result of NRC's technical assistance to CMHC in their materials evaluation program).

The new performance requirements, initially used by CMHC for acceptance purposes, were later introduced into the NRC Housing Standards and eventually became part of the National Building Code as an option to conventional engineering design as then expressed. The performance requirements necessitated the development of a test method as well, and this, too, survives essentially intact in the form of a CSA standard for roof truss tests [21].

This example illustrates that, (1) performance requirements that are set too high can be restrictive to innovations in construction, and (2) the development of realistic requirements can be time consuming and expensive even for a relatively simple structural performance requirement. The development of this performance requirement (like most others in the NBC) can be considered as being market driven, through builders' growing interest in roof trusses as a potential technological improvement.

Structural Design and Performance Requirements: It is sometimes not appreciated that the structural design requirements for buildings have for a number of years been essentially performance based. The performance levels in the form of design loads are stated in the code, and the design procedures for determining allowable stresses are provided through reference to design standards. While one may question the stated values for certain loads, loading conditions, or design procedures, the code nevertheless allows the structural designer freedom of choice within the limits of accepted knowledge. Design procedures not covered by the design standards are also permitted if the designer is qualified to use them. (NBC Article 2.5.2.1)

3.2 Formalization of Performance Requirements: Costs and Restrictions can Increase

Although experience in use provides one of the most reliable information sources for establishing performance levels, it must be recognized that many products are used in spite of some properties if other qualities outweigh these deficiencies. Using existing products as a yardstick to establish performance levels for newer products therefore may not always prove to be as straightforward as described in the examples for roof trusses. Gypsum board, for example, is used for interior finishing because of its economy, appearance and fire resistance properties, and in spite of its limited strength and water resistance qualities. Should a competing product be required in all-cases to provide equal fire resistance but no greater water resistance? Clearly, the end use should dictate the requirement.

Wood frame construction is used almost universally for house construction in Canada because of its economy, strength and versatility, and in spite of its combustibility, variability and decay potential. Glass is used because of its transparency, durability, and cost and in spite of its propensity to break into dangerous fragments.

If several products have been historically used for a particular building element, and it is intended to develop performance requirements based on their collective properties, the selection of the lowest common denominator of characteristics of the various products, would tend to result in an unreasonably low overall performance level. On the other hand, requiring the highest quality of each would set a performance level that could preclude each existing product as well as new products.

Performance requirements also should not underestimate the importance of the cost factor,

even though this may be difficult to take into consideration in establishing performance levels. This is a major factor in determining the extent to which certain limitations are tolerated in establishing the overall suitability of any product.

Whether the level of performance is based on a comparison with known products, on abstract evaluation of the characteristics deemed to be important, or by some other rationale, the required performance level should take into account all relevant characteristics that significantly impinge on health, safety, and ultimate affordability.

The development of realistic performance requirements can prove to be time consuming and expensive even when the material from which the product is to be made is known. When performance requirements are developed in the abstract, however, without a particular material in mind, the task can become impossibly complex. Applicable performance requirements for materials that are significantly affected by temperature, moisture, ultraviolet light, load duration and so on will be quite different from those that are not so affected. Without knowing the materials to be used, the performance requirements must therefore take into account all hypothetical materials, or be expressed in general terms that defy interpretation.

The enormity of the task of setting verifiable performance requirements in the abstract, without knowledge of specific materials or systems to be used, can be seen in the example of controlling indoor air quality. Where materials are used in locations where they may expose occupants of buildings to contaminants (such as harmful volatiles), the establishment of safe levels of contaminants can be enormously complicated, particularly for long term exposure. Unless the performance standard is made material specific then all possible contaminants harmful to health must be limited. It may simply not be possible to develop such abstract standards, therefore, and there may be no recourse but to rely on an evaluation system that is able to review such products on a case by case basis, drawing on the services of specialists for appropriate input. (This was discussed earlier under "Product Evaluation".)

Legget and Hutcheon (former Directors of NRC's Division of Building Research) (now IRC) have outlined some of the difficulties to be faced in establishing performance requirements, including the difficult problems of developing relevant tests [22]. They observe that

"It is much easier to specify a wood frame wall than to describe the limiting performance

characteristics of all acceptable alternative walls. For one thing, economics may have already restricted the choice, so that the procedure for admitting all possible solutions as a principle becomes unnecessarily complex and usually quite impracticable".

They further observed that

"Remarkable advances in science and technology generally have created the optimistic view that 'all things are possible', and encouraged an exaggerated idea of the comprehensiveness of knowledge about quite ordinary things like building materials and components. It would come as a great surprise to most people to know that no one is yet able to measure the properties of a particular asphalt or to predict with any certainty the durability of the products made from it except by observing and recording the way they stand up to years of service."

This is as true today as it was when first written eleven years ago.

3.3 Toward Performance Based Product Standards

Like the NBC, progress towards performance requirements in referenced standards has been slow. Progress towards - or away from - performance standards, like that indicated by NBC experiences, appears to be market driven rather than being philosophically motivated.

In this light it might be useful to examine a few relatively recent Canadian standards that have made significant advances towards a performance approach.

Window Standards: Prior to 1984 separate window standards were produced for individual window types based on the material from which they were made (wood, aluminum, steel, vinyl) and on the basis of type or grade of window. In all, about 13 separate standards existed. These were inconsistent in that they tended to set different standards for windows of different materials. Requirements affecting windows made with one material did not apply or were different from those made from another material so that some windows were treated more restrictively than others. In order to simplify this complex array of requirements, CMHC encouraged the development of a single omnibus standard to replace them. Scanada Consultants Limited was contracted to draft the new standard. This was subsequently published by CSA in 1984 (following the usual committee processing) and was incorporated

into the NBC as revisions in 1988 [23]. While the new standard still contains some material specific prescriptive requirements, for the first time all windows had to meet the same basic performance requirements for strength as well as for air and water infiltration limits, and all were rated for their performance on the same classification scale.

The introduction of the new standard, however, required an extensive program of retesting windows previously evaluated by CMHC under the former standards. In Dec. 1985, CMHC issued a notification that after July 1989 all new applications would have to conform to the new standard. Thereafter windows that had been evaluated to the former standards would have to show conformance to the new standard upon their reevaluation (5 years from the previous evaluation). The window industry, therefore, will continue to be in transition until 1992. This example illustrates the difficulty of an established industry made up of many small units in making fundamental changes to requirements. In changing a standard from a prescriptive to a performance approach, the testing necessary to show compliance can be a significant economic burden particularly for smaller manufacturers. The generous phasing in period allowed for in this case, however, helped to ease this problem.

Structural Sheathing: A second standard worth noting is that related to structural sheathing materials [24]. Over the years a progression of sheathing standards were introduced as alternative wood species were made into structural plywood and as various particleboard and waferboard products were developed. In the 1985 NBC, four separate standards were listed for plywood and waferboard sheathing and subflooring. The thickness requirements in the NBC for subflooring and roof and wall sheathing did not distinguish between species or, in the case of waferboard, fibre orientation. In fact, however, plywood strength does vary between species, and fibre orientation and density can affect the strength of waferboards. In order to provide a common basis for the performance of such materials and not penalize those whose product have superior performance characteristics, it was agreed to produce a standard based on strength and deflection characteristics. The products would not be specified in terms of thickness but would be designated in terms of the intended use and the maximum spacing of the framing supports. For example, a panel marked as 1F16 would be intended for subflooring on 16 inch centres. A panel stamped as 2F24, however, would be intended as subflooring at 24 inch centres for use with a separate underlay (hence the "2" designation). Similarly, the letter "W" would designate wall sheathing and "R", roof sheathing. Since each panel is required to meet the required strength and stiffness requirements specified in the standard, no thicknesses need to be listed in the NBC when graded to this standard. In this

way, panels can be designated to take full advantage of their individual properties for greatest economic benefits.

In this case, the CSA standard was following the lead of a U. S. standard on which it was based. Considerable testing was necessary to establish the performance limits which to a large extent were based on accepted U. S. code limits. Since Canadian requirements are somewhat less restrictive than those in the U. S., and treat waferboard, strandboard and plywood on essentially the same basis for strength, there is less economic incentive for such designations in Canada. Nevertheless, the new designations are recognized in the NBC. In this case, however, the existing plywood and waferboard standards were retained along with the old thickness tables for subflooring, and sheathing. Whether this proves to be a transitional or permanent condition remains to be seen. In this case, the new performance standard tended to complicate rather than simplify the requirements of the code. The new standard also represented a transfer of responsibility in that strength and stiffness criteria were being decided by the standards committees, not the NBC committee as in the past.

In this case as well as in the first case, the initiative for the performance approach was market driven, with the plywood, waferboard and strandboard manufacturers being the prime movers. The target in this case, however, appears to be primarily the export market.

Lumber Grading: Another area where a performance approach has been attempted is in the grading of lumber. Traditionally, lumber has been visually graded, taking into account the type, size and extent of certain defects such as knots, decay, holes, and cross grain. The size and extent of defects permitted in various grade characteristics were selected arbitrarily for both structural and aesthetic considerations, depending on the intended end use of the lumber. Standards for visually graded lumber therefore tend to be prescriptive rather than performance based.

Lumber, however, being a natural product, is variable. Two pieces of the same specie with identical defects can vary substantially in strength and stiffness. In order to establish safe working stresses, conservative values must be selected to ensure that a high percentage of the specimens will support the required loads. The structural application of visually graded lumber, therefore, is relatively inefficient. In recent years, in order to increase its structural efficiency, machines were developed to mechanically grade lumber by flexing each piece before automatically stamping it with appropriate strength and stiffness values. The use of

mechanical stress grading machines, therefore, substituted performance testing for prescriptive visual grading.

Since mechanically stress graded lumber sells at a slight premium there is relatively little economic incentive to use it in conventional frame construction. In the case of wood studs, for example, the strength of the wood is generally under utilized since the size of the members is governed by other factors (such as providing a reasonable nail target width, and an adequate depth for insulation). Floor joist spans, are often governed by stiffness rather than strength. Since visually graded lumber may have less conservative spans than mechanical graded, due to the assigned stiffness values there is little economic incentive to use mechanically graded floor joists. Generally stress graded lumber has been limited to the construction of roof and floor trusses where the more accurate strength designations can be more efficiently utilized.

The conversion to performance grading therefore has been carried out only to the extent that it is economically justified. Again the conversion has been market driven.

The trend in standards towards a performance approach is not without some reversals, however. When CSA first published their series of standards for mobile homes in 1970, many of the requirements for the basic structure were written in general performance terms. When the standards were considered for referencing in the NBC, the lack of measurable performance limits were considered to make the standards unenforceable. This, along with the belief that a separate performance level for mobile homes could not be justified led to the decision not to reference the standard in the NBC. Subsequent to the initial publication of the standard, numerous revisions have converted the original version of the standard into a prescriptive standard that generally parallels the requirements in Part 9 of the NBC [25]. The conversion to a prescriptive standard was motivated to a large extent by a desire for industry to obtain NHA financing. The conversion in this case, therefore, while being CMHC induced, was also market driven.

3.4 The Complexity of Inter-related Systems - How is Performance Measured?

The difficulties inherent in developing performance requirements that are both realistic and measurable may be underestimated if it is assumed that such requirements can be developed in isolation from one another, as in the case of the roof truss example.

In the field of fire safety, the component requirements form part of a complex and integrated system. The required performance level of any one of these may depend on the presence or absence of other fire safety features. The lack of knowledge in many of these areas makes the establishment of realistic performance levels most difficult even if the safety measures could be considered in isolation from one another. To express the level of fire safety for the entire interrelated fire safety system in measurable terms that are certifiably realistic, however, becomes almost impossibly complicated. The fire resistance rating required to contain a known hazard, for example, may depend not only on the fire load, but on the characteristics of the enclosing assembly, the size of the compartment, the presence of fire suppression and detection systems, and the travel distance to exits, to name but a few.

Historical Development of Fire Regulations: Fire safety requirements in North America were initially introduced to reduce the likelihood of conflagrations. These were to a large extent initiated and influenced by insurance companies to protect their investments. Property protection rather than life safety was therefore initially the prime consideration.

Over the course of time, life safety became the dominating interest as municipalities became more interested in the welfare of building occupants. It is difficult, however, to separate completely current fire safety requirements into neat compartments of property safety and life safety. Most requirements have a component of both, regardless of the initiating objective. There is in fact a spectrum of components. Some requirements (e.g. spatial separations) are quite clearly primarily concerned with preventing conflagrations and are essentially to protect property. Others (e.g. exiting) are essentially for life safety. In between are the vast majority of requirements with a component of each.

Many fire safety requirements in current codes were initiated as perceived answers to problems revealed by fire experiences where lives were lost or large property damage occurred. In other cases the requirements represent a hypothetical solution to a hypothetical problem. The experiences that shaped Canadian fire regulations were augmented by the experiences elsewhere as reflected in foreign and domestic codes or published incidents of fire events.

The development of most fire safety requirements, therefore, has been neither systematic nor particularly scientific. Rather, the growth in fire safety regulations has been pragmatic, reacting to reported fire events, perceived dangers and the constant flow of comments from

code users who have provided a major source of feed-back of experiences and viewpoints into the code making process. The numerous changes instigated through this process inevitably cause increased complexity which is often exacerbated by a mixture of drafting styles that occur over time with staff changes. While this has relatively little to do with whether a code is performance or prescriptive based, the more detailed the requirements become the greater the problem.

Fire Safety Performance Requirements in High Buildings: As the construction industry produced more and more high buildings in the postwar period there was mounting concern that the existing fire safety requirements were inadequate to provide a reasonable level of safety. Several fire experiences focused attention on the problems related to smoke movement as well as the evacuation of tall buildings in emergencies.

A number of requirements for tall buildings were introduced into the 1970 NBC relating to alarms, emergency communication, elevators for fire fighting, smoke venting, fire protection of emergency electrical services and additional limits for interior finishes. These were largely prescriptive in nature since it was not practicable to state such requirements in performance terms without creating serious problems of interpretation and application.

Amendments issued two years later, introduced performance requirements to limit the concentration of smoke contaminated air in certain critical areas of buildings (Appendix F). Although these were expressed in quantitative and measurable terms, the technology needed to design such systems was generally not understood by, or available to, rank and file designers. It was appreciated by code writers that such requirements could not be applied unless appropriate design aids were developed to assist in the interpretation of the performance statements. This, was not easy to accomplish without limiting the number of design options. The result was that a separate booklet was created, describing fourteen different ways to meet the smoke control requirements. (These are now incorporated in the current Supplement to the Code).

There are few indications, of designers who developed their own smoke control designs from scratch, so to speak, using the performance requirement in Appendix F. Most use the measures outlined in the NBC Supplement. This example illustrates the difficulties of interpretation that can result with performance requirements if the design technology to meet the stated performance level is not generally known to rank and file designers.

As with the development of other performance requirements, the process was time consuming and expensive. It may be considered, that the research was market driven because of the industry trends to higher buildings, (It is interesting to note that this work has formed the basis for smoke control requirements used in a number of other jurisdictions outside of Canada, and has made a significant contribution to the design procedures for smoke control described in the design manuals of the American Society of Heating, Refrigerating and Air-Conditioning Engineers).

3.5 Modelling the Performance of Whole Buildings: Fire Safety

The past two decades have seen a remarkable growth in fire technology. Great strides have been made in analyzing the factors affecting the initiation and growth of fires and the movement of smoke, as well as in the development of mathematical models to evaluate various relevant factors. Current research, particularly in the field of mathematical modelling, offers promise for the rationalization of code requirements, and should lead to much greater design freedom in future years.

Substantial advances have been made, for example, in the calculation of fire resistance ratings required for building elements to withstand anticipated fire exposures [26] [27]. By the use of such procedures it is possible to calculate the fire resistance rating needed if the fire load, venting and boundary conditions of the fire compartment are known. Although the current practice of specifying specific fire resistance ratings for building elements is performance based, the future calculation of such levels necessary to withstand a particular exposure risk allows an additional degree of design freedom, and therefore may be considered more realistically performance oriented, and therefore less restrictive.

Mathematical modelling can also be used to examine critically the value of existing fire safety measures. When sufficient knowledge is determined about factors affecting the development and spread of fire, it should be possible to evaluate the effectiveness of many of the current code requirements as well as the merits of proposed changes. This process has in fact already started. Proponents have already used this method of analysis as an argument to extend the use of their product through code revisions [28].

Of particular interest in the field of analytical modelling is the co-operative research program between NRC's National Fire Laboratory and the Footscray Institute of Technology of

Melbourne, Australia.

In 1986, the Australian group developed a computer program for a risk-cost assessment model for office buildings in Australia [29] [30]. The following year a co-operative program was initiated between NRC and the Footscray Institute to develop a similar model for Canadian apartment buildings [31].

The objective of the joint program is to allow any particular design concept to be evaluated in comparison with the requirements already in the National Building Code, both in terms of life risk and property damage. Although it does not attempt to establish absolute performance expectations for such buildings, it will for the first time allow a systematic evaluation of one design with another. If this approach is developed successfully, it will allow a designer the additional freedom of design choice now attributed to performance based requirements, but in terms that will allow quantitative evaluations. For a subject as complicated and interrelated as fire safety, this is no mean accomplishment and carries the potential for encouraging design innovations with attendant cost reduction benefits.

The general philosophical approach is not unlike that previously described for evaluating individual building materials in which the characteristics of an acceptable building product are measured and become the yardstick for evaluating alternative materials. The Australian method uses the existing level of fire safety inherent in current requirements as the yardstick against which innovations are evaluated.

According to Dr. David Yung, Researcher with NRC's National Fire Laboratory:

"The Assessment Model uses the stochastic approach which is a good compromise between the more scientific, deterministic approach and the non-scientific, opinionated approach. The comprehensive deterministic approach requires a complete understanding of the phenomenon which may take years to develop, if it is at all possible. Even with a complete understanding, the calculations are so complex that they may require excessive computation time and enormous effort to develop the computer program. The stochastic approach, on the other hand, uses a simpler, probabilistic technique to perform the risk assessment with input information based on statistical data and experience. The accuracy of the assessment depends on the quality of the input data and experience, but can be refined as more knowledge is available. This approach is especially valuable for

comparing alternative designs, as is intended in the present use, since in such comparisons the absolute accuracy of each individual assessment is not critical."

The successful completion of this assessment model should therefore permit the evaluation of existing requirements as well as proposed changes in terms of their overall impact on life safety and property damage potential. Fire safety requirements that can be shown to have little or no impact can be removed from codes with attendant reductions in construction costs. It should also help to identify areas where additional fire research is required in order to have the greatest impact on cost reductions.

The move to verifiable performance-based regulations is, then, strictly a knowledge-paced move, especially in the abstract and more especially where inter-related.

A Framework for Evaluating Building Regulations: A somewhat more ambitious project in modelling is that being undertaken by the Ontario Buildings Branch of the Ontario Ministry of Housing in co-operation with NRC's Institute for Research in Construction. In 1986 the Ontario Buildings Branch proposed the development of an all-inclusive framework for evaluating Canadian building regulations. Approved in principle by the various authorities responsible for provincial building regulations that year, the project was commenced by a joint group of Toronto consultants (TROW - IBI) the following year. The report on the first phase was completed in March 1989 [32] [33].

The assessment framework is intended to be all-inclusive, covering not only fire safety, but all aspects of the National Building Code. It is possible therefore, that with the future development of this approach, the joint Canadian-Australian project could form part of the fire safety component of the code assessment framework.

The objective of this project was to develop a building code assessment framework for evaluating the impact of requirements in building codes. The framework is described as "essentially a decision support system that helps in determining the appropriateness of including a requirement in the Building Code and assesses the economic and social impacts of such change." [33] The assessment framework consists of a code analysis component and an impact analysis component. The former was primarily developed for code writing agencies and requires familiarity with the code requirements and an intimate appreciation of the code objectives. It is a computer based data base that attempts to link requirements in

the code to specific code objectives.

The impact analysis component, on the other hand, is intended to assist code writers identify incremental technical, economic and social impacts of requirements by occupancy and building type. It attempts to identify the information required for quantitative assessments, and identify impacts related to specific code changes including changes in risk level. Included with this procedure are a number of data bases in addition to cost data for 18 reference buildings. Where there is a lack of data on which to make a quantitative assessment, the procedure depends on a Delphi technique for information. That is to say, it reverts to expert consensus opinion as opposed to hard facts, bringing it back to the current basis for making committee decisions.

The Building Code Assessment model is an attempt to provide a methodology for looking at the effects of code change on a wide ranging basis so that its total impact on society can be evaluated.

Other Modelling Attempts: It should also be noted that the U.S. National Institute for Standards and Technology (formerly the National Bureau of Standards) has also made significant strides in the modelling of costs and benefits of code requirements and these also show promise for future code rationalization [34] [35]. Information from the NBS modelling procedure for the effectiveness of sprinklers and smoke alarms [36] [37] has assisted in recent Canadian assessments of the effectiveness of residential sprinklers and smoke alarms in Canadian houses [38] [39].

It is not the purpose of this study to pass judgement on the approaches taken in any of the preceding projects. Suffice to say that all are attempting to rationalize the decision making process of code changes, and by so doing, make allowance for alternative solutions to code objectives. Some of these projects are more ambitious than others and will no doubt require a longer period to develop into a workable system that can be used with reasonable confidence and effect.

It is doubtful, however, if it will ever be practical to have all proposed changes subject to such methodical review process since this could stifle the committee process and make code changes much less responsive - not more - to code user needs. Complicated analytical processes should, therefore, be reserved for changes involving significant cost or benefit

effects. The increasing attention being given to such analytical processes, however, should have a sensitizing effect on code committees, and increase their awareness of the need to consider financial as well as risk consequences of the actions they take.

Knowledge vs. Methodology: While all of these modelling approaches offer promise for future code rationalization, one salient fact remains: knowledge cannot be magically created where none exists, regardless of the methodology used for modelling. It can only be created by patiently observing and collating data of events, both on-site and in laboratory controlled conditions. This is a long and tedious process and vast amounts of investigation are required to fill satisfactorily the knowledge gaps.

Many of the factors involved in fire modelling are variable and subject to probability of occurrence. Fire loads, can vary widely even within the same occupancy classification. Alarm, detection and suppression systems are subject to failure and this probability must also be taken into consideration. Human error and criminal acts must also be allowed for. Buildings change over their lifetime as well due to changes in occupancy, renovation and decoration. Extreme care must therefore be exercised before reliance can be given to any method that purports to have taken into account all eventualities that current building regulations try to allow for through seemingly redundant requirements.

Although most fire safety requirements may not have a scientific basis, there is nevertheless some reason for most. The authors of many of these have long since left the code development process, and the record of events during much of this period leaves much to be desired. There is a risk therefore that in assessing such requirements, their original purpose, and hence their true objective and validity may be overlooked in an analysis.

3.6 Establishing the Objectives of Existing Requirements: Commentaries:

While the precise reasons for many specific requirements have been lost as a result of poorly kept earlier records and the inevitable replacement of code committee members, there are nevertheless encouraging signs that significant progress is being made in defining code objectives to assist future code evaluators.

Better records are now maintained giving reasons for all code revisions, including the addition or deletion of requirements.

Starting with the 1980 edition of the National Building Code, useful explanatory material was included as an appendix to the NBC. The use of the appendix as a vehicle, not only for clarifying the requirements but for describing their objectives, has been growing with each new code edition. By having a better appreciation of certain requirements it becomes much easier for enforcing officials to make value judgements in assessing alternative design solutions.

Code commentaries are also a valuable mechanism in providing the code user a better appreciation of the general objectives of certain requirements. Currently, commentaries exist for Parts 3 and 4 and are being developed for Parts 5 and 9. These should be published within a year or so. While there appears to be a need for more formal guidelines to control the type of material that appears in the NBC Appendix or commentaries, they nevertheless have proven to be useful vehicles for consolidating code objectives.

In many cases it is fairly obvious what a particular Part, Section or even Subsection of the code is trying to achieve. The performance objective in such cases can usually be expressed with little or no difficulty. As requirements are dissected into smaller components, or as the general statements made more specific, the difficulty in articulating performance objectives, even in non-verifiable terms, becomes more difficult.

Beyond a certain size, for example, a building is required to be made of noncombustible construction. In general terms, it can be rationalized that this limits the contributions to fuel load, and prevents structural elements from fuelling their own destruction. Just why the particular building areas and height limits were chosen, cannot be determined. Similarly, the structural components in buildings up to a certain size are required to have a certain fire resistance rating, and in buildings over that size a greater rating. The increased rating can be rationalized generally on the basis of providing an increased safety factor, since the consequences of total collapse are more serious as the size increases, but no quantifiable determinations of limits were recorded.

In spite of the difficulties in articulating performance objectives, the advantages of doing so appear to be worth the attempt. A clear statement of purpose not only aids the designer in appreciating the reason for the requirement, it permits building officials and product evaluators to assess alternative design solutions with more confidence. Although the objectives may not be expressed in specific terms, they nevertheless increase the users

comprehension, and presumably his empathy towards the need for the requirement.

3.7 Regulating Existing Buildings

Existing buildings cover a wide range of construction types that vary in age, in their state of repair and in the risk they present to their occupants. When they are altered to accommodate a change in occupancy or for renovation it is a difficult challenge to establish the minimum standard for health and safety to which they should be expected to conform. Since such buildings vary so widely, a cost benefit solution for one may be completely inappropriate for another [6].

When the Associate Committee on the National Building Code responded to the growing demands of building officials to provide such requirements, it was generally agreed that it was just not practicable to provide such minimum requirements without creating an apparent double standard. It would also be difficult to justify the application of one set of requirements for older buildings and another for newer buildings and claim that the higher level is still a minimum standard.

The Associate Committee on the NBC decided instead to apply the requirements for new buildings to existing buildings, but only to the extent that this would be considered reasonable. In other words, the ACNBC decided to use the Code for new buildings as a guide to be applied with discretion to existing buildings, thereby avoiding the creation of a double standard. It is also intended that guidelines be published to aid code users in applying the NBC to existing buildings.

The ACNBC requested each technical committee to address this subject and take appropriate action. In reacting to this request, the committee responsible for addressing fire safety requirements decided that it was first necessary to define its fire safety objectives in specific performance terms, concentrating on the life safety component only, rather than property protection. This is a departure from the traditional requirements for new buildings which up to now has also considered the need for property protection. If, for example, there is concern only for the safe evacuation of occupants in fire, the resulting fire resistance needed for the structural components may be significantly reduced from that required for new buildings. At this stage, the proposal is in a development stage and it is too early to speculate on its eventual outcome. It is mentioned here to emphasize that code committees

are indeed considering performance options in lieu of prescriptive requirements.

4. BUILDING REGULATION IN OTHER COUNTRIES

Summary:

Assessing foreign building regulations from a Canadian perspective has inherent limitations since an accurate appreciation of the regulatory and design environment is not possible without actually having worked in it. Nevertheless, a review was made of regulations in the USA, Australia, New Zealand, Japan, Norway, Sweden, England and Wales. This showed a wide range of approaches in the various countries.

U.S. model codes are generally similar in content to the NBC, being a mixture of performance and prescriptive requirements. These are adopted in various ways by state and local governments so that many variations of these model codes are used throughout the some 45,000 U.S. jurisdictions.

The building regulations for England and Wales are expressed in non-verifiable performance terms. Deemed-to-satisfy solutions are issued as "approved documents" by the Ministry of the Environment. The existing New Zealand Code is due to be replaced by a new code based on the approach taken in England and Wales. The legal requirements are non-verifiable performance statements with proposed "approved documents" to provide means for verification as well as deemed-to-satisfy solutions.

The Australian Code is similar in content to North American Codes, being a mixture of performance and prescriptive rules. The long-term objective is to convert to verifiable performance requirements as knowledge permits, and to clarify and simplify code language.

Norwegian requirements, while mostly performance based are a mixture of the two. The performance requirements are both verifiable and non-verifiable, with the administering authority having considerable discretionary power.

The Swedish approach appears to decentralize the regulating process. The requirements are essentially performance based, with deemed-to-satisfy solutions made at the local level.

The Japanese requirements are more comprehensive than most, and cover zoning and building maintenance in addition to usual building code type requirements. The Japanese regulations are somewhat more prescriptive than the NBC.

4.1 Intent and Limitations of this Overview

It is perhaps naive to assume that an adequate assessment can be made of another country's

building regulatory system through a review of the literature and a limited number of personal interviews. Although this can provide some insight, it is no substitute for first hand experience in working with the documents in question in their proper legal and cultural milieu.

An appreciation of such regulations should also consider the design environment in which the code is used, where the designer is governed not only by codes, but by the rules and customs of his profession. These have evolved over the years in response to conditions peculiar to that country. Other regulations, constraints and incentives are also at work to influence the course of building construction found there.

Although care has been taken to use authoritative literature sources and knowledgeable people as sources of information in the review of foreign code approaches, the reader should appreciate that this study is based on a fairly limited depth of research.

Transplanting the approach taken by any of these countries to control building construction in Canada, is risky, or at least presumptuous. Without first hand experience of the total regulatory and design process, it is simply not possible to assess their regulatory impact in a Canadian context.

It is with this caveat that the following review is presented.

4.2 The U. S. Approach

Within the US, there are over 44,000 units of state and local governments that adopt, enforce or amend building regulations. According to the Executive Director of the National Conference of States on Building Codes and Standards (NCSBCS), the building regulatory system is "a chaotic patchwork of overlapping and conflicting rules, regulations, codes and standards and administrative procedures" [40] (NCSNBS is an executive branch of the National Governors' Association. Its objectives are to encourage interstate cooperation, and to coordinate intergovernmental reforms in building codes and standards.)

The Executive Director of NCSBSC further points out that, "while 39 states have some form of statewide building regulation, their regulatory authority, the codes they use, the modifications (amendments) they make to those codes and the types of buildings they cover

vary widely with no two states having identical regulatory programs."

Although under the U. S. constitution, building regulations are the responsibility of state governments, the states do not exercise their power uniformly. In certain states, for example, only certain specific areas of life safety, accessibility, health or energy conservation are addressed. In many states, local authorities can amend the state code or may be free to adopt their own code. Some states adopt model codes or standards in an unamended state but allow local authorities to tailor the document for local conditions.

The development and adoption of building regulations by state authorities may be done by more than one agency, and in fact may involve a number of codes, all of which contribute to the variety of building regulations. In some cases, all building regulations are under the jurisdiction of one state agency and include building, mechanical, plumbing, fire prevention, life safety, accessibility and energy conservation. Other states have separate codes for each of these areas. Many state and local jurisdictions that do adopt model codes do not keep these updated to the current version, thus increasing the diversity of requirements. This is a similar problem experienced in Canada before provincial authorities withdrew building regulatory authority from local jurisdictions and instituted programs to adopt provincial building codes based on the latest version of the NBC.

Not everyone shares the bleak picture of apparent chaos and non-uniformity in U. S. building regulations, painted by the NCSBCS Executive Director, however. There are some signs that harmonization influences are at work [41]. These will be discussed later.

Nevertheless, in comparison to Canada, the U. S. seems to have a long way to go to reach the level of uniformity attained in building regulations in this country. The strong tradition of local independence in the U. S. , and its resistance to centralized authority would seem to indicate that the road to uniform regulations will indeed be a long one. This, combined with the fact that the U. S. currently has three competing model codes, portends that a uniform approach to regulation will be much more difficult to achieve than has been the case in Canada. Whether or not complete uniformity is a desirable objective, however, is another subject. It may well be that some variation in requirements may in fact provide a stimulus for innovations. By allowing an opportunity for variations, some design solutions are tried that may not otherwise have been permitted.

U. S. Model Codes: The most significant influence in developing a harmonization in US building regulations is that provided by the three major code writing agencies. The International Conference of Building Officials (ICBO) publishes the Uniform Building Code. First issued in 1927, the UBC is mainly adopted in the Western states, and tends to emphasize the design of earthquake resistant structures [42]. The Southern Building Code Congress International (SBCCI) publishes the Standard Building Code. This is used principally in the Southern states, where it was introduced in 1940. Finally, the Building Officials and Code Administrators (BOCA) issue what is now known as the National Building Code. Formerly known as the Basic Building Code, it originated in 1950. It is used primarily in the Northeast and Midwest states. All three codes are intended to provide minimum acceptable standards for health, safety and public welfare.

In addition to building codes each agency also publishes a variety of other codes such as plumbing, mechanical and fire prevention codes as well as other code related documents. All three model codes are updated on a three year cycle as compared to the five year cycle for the NBC of Canada.

Each of the model code writing agencies provides an evaluation service for new products and systems as well as a variety of other services to assist adopting authorities to administer their respective codes. The three model code agencies also operate a "National Evaluation Service" under the umbrella of the Council of American Building Officials, through a secretariat that revolves from one agency to another at fixed intervals. A proponent using this service can have a product evaluated by each agency and be issued a "National Evaluation Report". This is somewhat less expensive than obtaining a separate report from each agency.

Although the National Fire Protection Association (NFPA) also publishes a Life Safety Code, this is usually not considered as a true building code since it does not address the subject of structural requirements. Nevertheless, its fire safety provisions have a significant influence on all model codes including the NBC of Canada.

The content of the U. S. model codes is not unlike that of the NBC of Canada in that they are a mixture of both prescriptive and performance requirements. Although they differ from one another in specific requirements as well as in format and arrangement, they nevertheless cover the same general areas familiar to users of the NBC of Canada.

Reference Standards: Like the NBC of Canada, the U. S. model codes reference numerous standards prepared by other agencies. It has been estimated that a typical U. S. building code references from 300 to 400 primary standards.[43] These include materials specifications, test methods, and numerous installation and design standards, including structural design. Many of these are the same standards used as the basis for design contracts and construction specifications as well as in building regulations. They are used as the basis of product certification as well, and generally parallel the application of Canadian standards.

U. S. Harmonizing and Unifying Efforts: In an attempt to reduce differences in terminology between model codes, the Council of American Building Officials have formed the "Board for Coordination of the Model Codes". The Board has equal representation from each of the model code user groups.

NCSBCS (mentioned earlier) has also worked over its 23 years of existence with model code groups, trade associations and others to draft model code legislation. NCSBCS has apparently been instrumental in helping a number of states to develop and adopt statewide programs, and had spearheaded efforts for national uniformity in energy conservation and prefabricated buildings [40].

In addition to the efforts of these two agencies, the federal government has promoted the adoption of model codes during the 1980's by providing funds to cities and towns to modernize their codes. It also made the adoption of such codes a condition for obtaining funds from the federal Urban Renewal Program. Other federal programs also encouraged the adoption of such codes [41].

The U. S. General Services Administration responsible for all federal building construction is now required by law to conform to one of the three model codes (44). This decision will no doubt also have a significant effect in the harmonizing process, due to the volume of building involved.

Who Decides?: While revisions to the model codes can be initiated by any concerned person, the voting on any proposed change is restricted to "active members" [41]. The latter must be actively engaged in municipal code enforcement. This is one of the fundamental differences between U. S. and Canadian code development practices. Whereas ACNBC and ACNFC policy is to provide a balance between regulatory, industrial

and general interest sectors, U. S. practice ensures that all decisions will be made by those engaged in local code enforcement. The Canadian approach is designed to ensure that this does not happen, and that no one group will dominate committee decisions [45]. Although the U. S. model code process for initiating and reviewing proposed changes is fairly open so that all are free to participate in discussions, there appears to be a fundamental weakness in the process whereby the policeman writes as well as enforces the law.

In NFPA committees who produce the Life Safety Code, previously referred to, as well as other important fire safety standards referred to in the various model codes, voting members represent a much wider spectrum of interests, and various facets of the construction industry are usually represented. In addition various safeguards are built into the review process to ensure that all viewpoints are heard.

This is generally true for other major standards writing agencies as well where the consensus method of decision making, approved by the American National Standards Institute, is observed. (ANSI is the coordinating body for consensus standards produced by various nationally recognized organizations in the U.S.)

Performance Trend: Like Canada, the U. S. has had earlier experience with the use of performance codes. In the late 1960s, the U. S. Department of Housing and Urban Development (HUD) conceived a program to bring about changes and improvements in housing through encouraging innovation in design and construction. This project, conceived in 1969, was known as **Operation Breakthrough** [46].

It was recognized early in the program that no adequate performance-oriented standards existed by which innovative constructions could be evaluated. HUD therefore commissioned the National Bureau of Standards (now the National Institute for Standards and Technology) to develop the desired standards. These were published in the early 1970s in four volumes under the title, "Guide Criteria for the Evaluation of Operation Breakthrough". One volume was published for multifamily high rise, one for multifamily low rise, one for single family attached and the final volume for single family detached houses.

With the objective of having the criteria reflect the consensus of opinions of leading professionals, the National Academy of Science and the National Academy of Engineering were enlisted to oversee the project. A joint "Advisory Committee to the Department of

Housing and Urban Development" was created to review and comment on the criteria.

Following the lead of this program, the HUD Minimum Property Standards then in existence were converted from specification oriented standards to performance standards to the extent that this was practical.

The performance criteria used for Operation Breakthrough and in the Minimum Property Standards were expressed in measurable terms, wherever possible, and were therefore both useable and enforceable. The Operation Breakthrough project, however, appeared to have little lasting effect on the construction process.

None of the major model code groups adopted the criteria developed for this project, nor does there appear to be any evidence of individual local governments having shown any particular interest in the performance approach.

Under the Reagan administration, deregulation became the new watchword and federal government activity in building regulations waned. The HUD Minimum Property Standards were withdrawn in favour of local building regulations. Thus a major experiment in performance based building construction requirements ended and the national impetus for such requirements declined.

A more recent example of a performance approach being applied to building regulations in the U. S. is that of a code change proposed for inclusion in the Appendix to the ICBO Uniform Building Code to control radon build-up in house basements [48]. This proposed change for the 1991 cycle of changes is somewhat novel in that it provides not only a performance approach, but deemed to satisfy requirement as well.

The performance option establishes maximum radon levels when measured in conformance with a yet-to-be-developed test standard. Since the knowledge to predict radon gas concentrations does not exist for all practical purposes, the proponent who elects to use the performance approach can only ascertain whether or not the limits have been met by testing the house after completion. Because of this, it is proposed that the proponent post a substantial bond to ensure that corrective action will be taken should this prove necessary. If the proponent elects to use the prescriptive option, (which are not unlike the requirement in Part 9 of the NBC), the proponent can ignore the resulting radon levels and need not

perform any tests or post a bond.

While this approach offers the opportunity for various design options, the additional administrative work needed to process deposit payments, and the length of time required to test the radon levels (1 year) may make the performance option somewhat academic except in areas where there are no known radon problems. Nevertheless, this approach is an interesting example of the current interest of code authorities to allow additional design solutions.

Costs of Code Administration: American interest in the use of the private sector for code compliance inspections appears to be growing. The objective appears to be to provide more efficient inspection services, particularly during periods of construction expansion. Various methods of providing for private inspection services have been proposed or are being tried.[48] The proposals include the use of project coordinators, registered industrial plant coordinators, third party inspectors and site work certification.

Private sector project coordinators are hired by developers as designated contacts with the municipal officials and work closely with them to schedule inspections, coordinate plan revisions and expedite corrections.

Industrial plant coordinators are registered private sector personnel employed to certify compliance of equipment modifications or changes in manufacturing processes. By certifying compliance, it is possible to waive minor permit and inspection requirements. (This procedure is limited to existing buildings.)

With third-party inspections, certain builders are authorized to retain certified inspectors who are approved and registered with a municipality to perform required inspections. Since the scope usually involves new buildings, this method of assuring code compliance is considered to be more controversial than the others mentioned, and is generally limited to certain kinds of construction.

Site work certification is similar to third party inspection in that the individuals are approved and registered in the municipality in which they operate. Such inspectors are employed by developers to certify certain site improvements.

The use of a third party to provide independent building inspections is not new to Canada. This service has been available through CSA for many years to inspect and certify factory built houses, mobile homes and construction camps on behalf of provincial authorities.

Whether or not the use of private agencies to carry out inspections and plans examinations normally undertaken by public authorities, will lead to substantial savings, however, is not known.

4.3 Japan

Of the various building codes reviewed in this study, none appear to be as detailed and comprehensive as the Building Standard Law of Japan. It not only covers typical building code requirements for health, fire safety and structural sufficiency found in American and Canadian Codes, but contains comprehensive zoning and administration requirements as well. It also regulates certain buildings after they are constructed, requiring periodic inspection throughout their entire life cycle to ensure continuing compliance with the law.

The Building Standard Law of Japan, initially enacted in 1950 by the Japanese Diet appears to have been influenced by the Uniform Building Code published by the International Conference of Building Officials (ICBO). The Uniform Building Code has traditionally emphasized seismic design requirements, a subject of particular concern to Japan.

The 1986 English language translation of the Building Standards Law is divided into three distinct parts: The Building Standard Law, Building Standard Law Enforcement Order, and the Building Standard Law Enforcement Regulations [49]. The first part is the basic enabling law that describes the areas of regulation and machinery for administering the requirements. These requirements are supplemented by the Enforcement Orders and Enforcement Regulations in the subsequent parts. The Orders and the Regulations form the substance of the technical requirements.

The administration of the Building Standards Law rests with the powerful Ministry of Construction, with the final authority on most matters being the Minister. Day to day administration, however, is delegated to the 265 or so local and prefectural administrative agencies.

The building code type requirements cover essentially the types of requirements covered in most American codes. Like other typical American codes, the Japanese requirements are a mixture of performance and prescriptive requirements with the latter forming the major portion. As a general observation, the Japanese requirements appear to be even more prescriptive in nature than their American counterparts.

The zoning requirements are extensive and cover the creation of fire zones as well as zones based on aesthetics and general land use.

The objective of the Japanese requirements are "to protect life, health and properties of the people by providing minimum standards concerning site, structures, equipment and use of buildings and thereby to contribute to the furtherance of public welfare" [50]. the requirements therefore go further than American and Canadian codes by including zoning requirements and cover such additional subjects as the right to sunlight.

The requirements are mandatory for all buildings in Japan, although local or prefectural governments are permitted to make amendments for their particular area if it can be shown that certain subjects are not covered adequately in the Building Standards Law. For instance snow loads and seismic design loads vary, depending on local conditions. Essential safety requirements, however, such as those relating to fire safety cannot be amended by local authorities.

The Building Standards Law is supplemented by various technical standards or "Ministry of Construction Notifications". Of particular interest to Canada is Notification No. 56, "Technical Standards for Ensuring Structural Safety in Wood-frame Construction", which impacts on the use of Canadian lumber in Japan.

Evaluations: Additional requirements, interpretations or product acceptances can be enacted by "Minister's Order". A proponent wishing to have a new product system or design approved for use in Japan, for example, must submit it to the Ministry of Construction. In most cases, the Ministry will ask another agency such as the Building Centre of Japan to evaluate it and make its recommendations. If, based on this advice and its own judgement, the Ministry accepts the proposal, a Minister's Order is issued that mandates its acceptance throughout Japan. In most cases such evaluations are arrived at on the basis of the opinions of a small committee of experts, usually appointed by the Building Centre of Japan.

Administration: Although most building plans are required to be approved prior to construction, those for certain smaller buildings are not. For example, wooden buildings less than 3 storeys in height and not more than 500m² in floor area, and non-wooden buildings of not more than one storey and 200m² in floor area are apparently not subject to such prior approval. If the building has a "special" use (e.g. used as a theatre, hall, hospital or department store), it is subject to prior approval if the floor area exceeds 100m². If any building is built within a "city planning area", however it must have prior approval unless exempted by the prefectural governor.

Most single family houses would therefore appear to be exempt from the requirement for prior approval. Maintaining the appropriate standards is the responsibility of the builder or contractor, subject to the requirements of the trades licensing agency. Builder reputation, however, is also an important factor in maintaining quality.

Another control is exercised through the licensing of architects under the Architects' Law. A "first class" licensed architect, for example, is authorized to take charge of the design and site supervision of any building. A "second class" licensed architect can do the same for all wooden construction as well as smaller non-wooden structures. Licensed "wood" architects are responsible for small size wooden buildings [51]. Buildings beyond a certain size are required to be designed by licensed architects under the Architects Law.

Building Maintenance: Buildings such as hospitals, hotels, department stores, theatres, multi-family residential buildings and offices that exceed certain size limits are subject to periodic inspection after completion and occupancy to ensure continuing compliance with the Building Standard Law. Programs for maintenance must be prepared and submitted to appropriate authorities for approval. In addition, elevators, escalators and other building equipment in all buildings are also subject to periodic inspection to maintain appropriate levels of safety.

Reference Standards: Like other building codes, the Building Standard Law makes frequent references to other standards. The major producer of standards is the Japanese Standards Association who publish the Japanese Industrial Standards (JIS). The organization appears to be similar in operation to CSA. Another organization publishes the Japanese Agricultural and Forestry Standards (JAS), and are responsible for wood based products such as plywood,

flooring, laminated wood and lumber grading.

Energy Use: Energy conservation requirements affecting buildings are covered by separate legislation published in 1979. This "Law Concerning the Rationalization and Use of Energy", establishes criteria for reducing heat loss through the building envelope, along with guidelines for the design and construction of houses to conserve energy.

Future Code Development: It should be noted that the building regulatory system in Japan is currently undergoing a comprehensive review. At this stage, however, it is not known what future direction the regulations will take. Japan is known as country with many solidly based traditions, and certain trades such as house construction are particularly well rooted. It is to be expected, therefore, that any radical change in the building regulatory process will probably require a substantial time interval to bring about.

4.4 Australia and New Zealand

The Australian and New Zealand progress towards uniform national building codes appears to be somewhat behind that for Canada, although in recent years substantial progress appears to have been made in both countries.

Australia: Until the late 1970s Australian building regulations were under local jurisdiction and initiative. They were commonly modelled after obsolete British codes, modified to allow for local influences [52].

The influences that promoted the cause of uniformity were essentially the same that arose in Canada. These included perceived economics in construction and greater freedom for the different facets of the construction industry to operate throughout the various code jurisdictions.

The unifying process appeared to have started in 1964 when submissions recommending uniform building regulations were presented at the Conference of State Ministers of Local Government. This led to the production of the Australian Model Uniform Building Code in the early 1970s, based on the Uniform Building Regulations of Victoria. It was not until 1984 however, that all jurisdictions introduced building regulations based on the model code.

Like the NBC of Canada, the Australian model code has no legal status unless adopted by the state or territorial governments. Like Canadian provinces and territories, each jurisdiction may add to, subtract from, or alter the model code provisions.

In 1980 the committee responsible for the Australian model code was restructured to give it broader representation, and was renamed as the Australian Uniform Building Regulations Coordinating Council (AUBRCC). The National Building Technology Centre of the Commonwealth Scientific and Industrial Research Organization (CSIRO) was named Technical Advisor to the Council, a function similar to that provided by IRC to the ACNBC.

Through an agreement with the state and territorial governments, AUBRCC defined a number of objectives to be pursued in developing its model code. It was agreed that the regulations in all jurisdictions should be the same, with any changes limited to those necessary for climate, geological or geographic reasons. It was also agreed that the requirements should be based on performance requirements with deemed-to-satisfy provisions to facilitate design and enforcement. In addition only those requirements needed for health and safety or essential to occupants' amenity should be included and these should be cost effective and easy to understand. In addition to these code objectives, AUBRCC also agreed to examine the need for a national accreditation system for evaluating building materials and construction methods.

The 1988 Building Code of Australia, the new title for the model code, goes part way in achieving these objectives. Any amendments enacted by state and territory jurisdictions will be identified in the new edition and included in a new appendix, thereby facilitating designers in one jurisdiction in designing buildings for another jurisdiction.

Although statements regarding the objectives of the requirements are included at the beginning of each section in the new code, these do not establish verifiable performance levels. In some cases provisions are expressed in measurable performance terms with deemed-to-satisfy provisions, but in general the Australian Code is about as performance oriented as other model codes in the U.S. and Canada.

The new code, therefore, is considered to be only the first stage in an on-going comprehensive reformation and simplification process which is intended to be advanced in future code editions. The process of converting prescriptive requirements to performance

requirements with deemed-to-satisfy provisions is also intended to continue. The AUBRCC has initiated a number of research projects to review and develop parts of the code and to improve its layout and presentation [53].

The current code has followed a similar course that the NBC of Canada followed in 1980 by removing most administrative requirements and limiting the document to technical requirements only. Like the NBC, the current Australian Code allows for the use of equivalent products and systems where these can be shown to provide the same level of protection.

A plan to permit private professional certifiers to issue certificates as evidence of compliance, similar to the system used in the UK, is currently undergoing trial use. The Australians plan to introduce the system first in Melbourne and then in other areas. Although insurance coverage has been mentioned as a stumbling block, this is expected to be resolved in due course [52].

The reorganization of the code, and the removal of its ambiguities is considered to be the first step needed to permit the preparation of software to help designers and enforcement officials to use the code. AUBRCC and CSIRO are currently working together to prepare an expert system to allow users an easier access to the code requirements [54].

New Zealand: The model building bylaw in use in New Zealand is the NZS Model Building Bylaw produced by the Standards Association of New Zealand (SANZ) who also produce the related means of compliance standards. There are, however, 90 district and regional building code authorities, 19 government departments and about 400 other statutory agencies with specialized functions, all of which can alter these building requirements or prepare additional ones for particular social objectives [54].

The complex array of requirements together with their generally prescriptive nature has given rise to industry and government pressure for reform of the building regulatory process.

In 1979, a research program to study the building regulatory system was initiated at the Victoria University School of Architecture in Wellington, sponsored by the Ministry of Works and Development. A review team was also appointed by the government (1982) which subsequently interviewed about 1000 persons and analyzed 70 submissions from a

variety of interests across the country. One major recommendation made by the reviewers was that a performance based building code should be produced based on the model developed by the Nordic countries (which is discussed later).

New Zealand Building Industry Commission Study: The reviewers also recommended that a Commission be established to continue the study into the building regulatory process. In 1986, the government established a 5 member Building Industry Commission whose primary objective was to "(a) determine within a suitable economic framework the most appropriate legal and regulatory provisions for buildings and building construction and maintenance consistent with public interest (including health, safety and amenity aspects); and (b) in those areas where it is considered that such objectives are best achieved through minimum performance standards, prepare an appropriate, simplified, uniform performance-oriented national building code which will bind the Crown."

As a result of this mandate, the Commission published a 2 volume report to the Minister of Internal Affairs in Jan. 1990 [55]. The first volume described how the work was carried out and the conclusions reached, while the second consisted of a draft "Building Act", draft "Building Code Regulations", and draft "Examples of Verification Methods and Acceptable Solutions". Volume 2 is intended to form the basis of legislation to be introduced into Parliament later.

The Act establishes the machinery for developing and administering the Building Code Regulations and assigns powers and responsibilities. The Building Code Regulations that accompany the Act have two attached schedules; the first illustrating the approved forms to be used, and the second entitled "Building Code". This second schedule is in effect the performance code without the administrative requirements. The "Examples of Verification Methods and Acceptable Solutions" are not part of the Act, but are intended for inclusion in "Approved Documents".

Proposed Building Regulations for New Zealand: The so-called Nordic Building Code model on which the proposed New Zealand Building Code is designed, is based on a hierarchy of five levels of requirements. The first three levels set out all the mandatory legal requirements and form the basis for "the Building Code" as noted previously.

The first level states the purpose, which describes the social objectives of the requirement,

usually expressed in terms of human needs. The second level states the **functional requirements**, which describes the function of the building and its parts required to meet the social objective, or "purpose". The third level states the **performance** required, which describes the behaviour of buildings or their parts that will fulfil the functional requirements.

Level four, showing the **means for verification** of performance, and level five, providing acceptable solutions or **deemed-to-satisfy requirements** are not part of the code but are intended for inclusion in "Approved Documents" to be determined later by the administering authority. These will include a number of existing SANZ standards. The examples of level 4 and 5 requirements provided in the report (Part 3 in volume 2) are not complete and are to be developed later.

The New Zealand study was not concerned with existing building codes only. It also covered the various acts and regulations of the various departments and agencies that impact on buildings. The study was, in fact a fundamental review of the entire regulatory process for buildings in New Zealand, including the legislative and administrative machinery for producing and enforcing building regulations including financing.

The use of approved independent certifiers has also been endorsed by the New Zealand Building Industry Commission. This is apparently modelled after the British whereby certifiers could either work on behalf of the local authority, or be hired by an owner not wishing to deal directly with the local authority. Like the British scheme, the certifier would have to be indemnified to protect the owners' interest in the event of future damage claims. It was suggested that allowing competition in inspection services will lead to greater costs effectiveness.

General Observations: Restricting these comments only to the building code aspects of the study, it would seem that in the Canadian context, the requirements would present a number of enforcement problems. However, it is perhaps not fair to be too critical of the proposed approach since there may be changes introduced before it is presented to Parliament for action.

On the basis of a general overview, it would appear that a designer would be presented with a most formidable challenge to prove compliance with the code while the administrative officials appear to have inadequate tools to enforce the desired levels of performance. It

remains to be seen, therefore, should the proposed code be accepted, just how effective the regulation of buildings would be.

In spite of the close relationship between AUBRCC and the New Zealand Code group, New Zealand appears to have chosen to take an independent path in developing its approach to building regulations, and views the current Australian model code as basically a technical rewrite of its older model code, and not really fundamentally changed. In spite of the acknowledged desire for harmonization, however, the New Zealand Building Industry Commission has elected to pursue a much different course of action than the Australians although the long term objectives of both appear to be similar.

4.5 England and Wales

In the latter half of the 1970s a great deal of critical comment appeared in the U.K. technical press regarding the state of British building regulations. They were considered by many to be excessively complicated and unduly restrictive. This groundswell of criticism coincided with a change in government in 1979, which led to the appointment of a Secretary of State for the Department of the Environment who sympathized with these concerns.

A new Building Act was therefore introduced in 1984, incorporating requirements from 46 other Acts or Instruments, but mainly from the "Public Health Act", the "Health and Safety at Work Act", and the "Housing and Building Control Act".

The new Act (or enabling legislation) introduced a number of fairly radical concepts in regulating buildings and provided an opportunity to revamp completely the existing building regulations.

Only 20 regulations were introduced in support of the Act. These were made effective throughout England and Wales on Jan. 1, 1986.

Regulation No. 7 simply states that "Any building work shall be carried out with proper materials and in a workmanlike manner". The other regulations, apart from Regulation No. 4, are administrative in nature.

Regulation No. 4 requires buildings to comply with two "schedules". Schedule 1 of the

Regulations contains the substantive requirements that regulate building construction for health and safety purposes. Schedule 1, therefore, along with Regulation No. 7, forms what in effect is an equivalent to a performance building code. (Schedule 2 relates to requirements for the disabled and will be discussed later)

Schedule 1 is divided into parts A to L, each relating to a specific subject area. All requirements in Parts A to K of Schedule 1 are stated in non-specific and non-measurable terms using words such as, "sufficient", "reasonable", "adequate" and "suitable", rather than quantitative terms or dimensions. Part L, however, relating to energy use is somewhat of a hybrid, a mixture of specific and non-specific requirements.

Under the Act, the Secretary of State is empowered to issue "approved documents" to expand on the non-specific terminology in the Regulations. At least 12 such "approved documents" have been issued to date in addition to "Building Regulations 1985, Mandatory Rules for Means of Escape in Case of Fire". Unlike the "approved documents" the latter is a list of mandatory requirements for certain building categories, and no deviations or alternative design solutions are permitted. (Recently, however, certain amendments have been proposed whereby these rules would be included in an "approved document", as non-mandatory or one "deemed-to-satisfy" solution) [56].

The "approved documents" are issued for each part of Schedule 1, (as well as for Regulation No.7) and cover subject areas that deal with "materials and workmanship", "structure", "fire spread", "site preparation and resistance to moisture", "toxic substances", "resistance to sound passage", "ventilation", "hygiene", "drainage and waste disposal", "heat producing appliances", "stairways, ramps and guarding", and "conservation of fuel and power".

Schedule 2 of the Regulations, the only other schedule that deals with substantive design and construction requirements, specifies facilities to be provided for disabled people. No "approved document" has been issued for this schedule. Instead, reference is made in Schedule 2 to design notes issued by another department and to a British Standard as deemed-to-satisfy solutions for the occupancies affected.

The so-called "approved documents," as noted earlier, are not mandatory requirements. Indeed, such documents can be prepared under the Act by any other agency designated by the Secretary of State. (This power has not been exercised as far as can be determined,

although presumably it was intended to apply to agencies such as the British Standards Institute.)

The "approved documents" can provide three kinds of design assistance. They can give an amplification of the requirements in Schedule 1 by way of explanation of intent. They can provide technical solutions by providing details on accepted methods and construction details (i.e. deemed-to-satisfy solutions). They can also give alternative approaches by referring to other standards (or provide appropriate material extracted from these standards).

Although the "regulations" to the Act have been reduced to a very meagre size, the associated documents increase the amount of technical paper a designer has to contend with well beyond that under the previous 1976 regulations. Apparently this is somewhat contrary to the original concept of having the designer take responsibility through his normal design responsibilities to establish safe buildings [57].

Private Inspection: Under the new Act, the private sector is empowered to undertake buildings inspection functions in competition with local governments. The system is based on the work being done by approved certifiers having no direct vested interest in the work. Under this system, developers have the option of engaging such certifiers rather than dealing directly with municipal authorities. Certification latitude depends on professional qualifications, practical experiences and appropriate insurance coverage. The scope of the work permitted therefore depends on the qualifications of the individual certifier.

This private certification is apparently slow in developing due to insurance requirements for the certifier. For the initial period, only the National House Building Council qualified as a private certifier, and this was made possible by a special arrangement.

In addition to such approved certifiers, self-certification is also permitted by specified public bodies such as British Gas, British Rail and the National Coal Board.

Plans Approval: Another interesting procedure under the Act relates to the submission of plans. The designers can submit a complete set of plans for approval, or he can submit a very much reduced partial set on which only specified, rudimentary information is required. If the first option is taken (full set of plans) the designer is at no risk of having to change any of the details later when the finished building is complete, provided it conforms to the plans.

If, however, the second option is taken, the builder is not protected and there is a risk that subsequent inspection may require expensive changes to be made. If the building is in a category that requires the mandatory egress provisions (mentioned earlier), then a full set of plans must be submitted for approval in all cases.

Other Documents: In order to facilitate the application of the Act, a "Manual to the Building Regulations, 1985" has been published by the Department of the Environment. This provides a complete guide to the procedures required to obtain approval under the Building Regulations. It covers the application of the Regulations, and the procedures to be followed as well as the Regulations and supporting documents.

Other Regulations: While the new Building Act had the effect of consolidating the requirements found in other acts, and is intended to be comprehensive, there are nevertheless other acts that still affect buildings. These include the Factories Act, the Offices, Shops and Railways Premises Act, the Clean Air Act, the Town and Country Planning Acts, the Cinematography Acts, the Fire Precautions Act, the Water Acts, the Control of Pollution Act, the Education Act, and the Local Government, Planning and Land Act.

In addition to these, other acts have been passed (with parliamentary consent) by local councils representing large urban populations. These acts, about 25 in all, were introduced where existing acts were considered to be inadequate. They cover subjects such as safety in parking areas, fire fighting access, fire safety in large buildings, egress requirements for certain buildings, drainage systems, retaining walls, and the paving of yards and passages.

General Observations: The new Building Regulations appear to have been the inspiration for the approach suggested in the proposed New Zealand building code mentioned earlier. Although the format is a little different, the basic concept of non-specific performance requirements supplemented by approved documents is essentially the same.

The general observations made in the case of the New Zealand approach, therefore, appear to apply here as well. The basic law, including the regulations and their performance code schedule, is essentially unenforceable by themselves. The "approved documents" that expand on these performance statements are not part of the legal requirements but are merely solutions considered by the Secretary of State to meet the requirements. Whether or not these are minimum or in excess of minimum has not been legally established.

(The approach in essence is not too different from that previously mentioned in relation to Part 9 of the National Building Code in the 1965 edition. The "Residential Standards" in the 1965 NBC served the same role as the "approved documents" in the new U.K. Building Act.)

4.6 Sweden

Rationalization is perhaps a hallmark term in thinking of Sweden's approach to production and quality control. It was hoped that it would be particularly instructive to consider how that country attempts to regulate building quality without stifling innovation.

As will be seen, Sweden is just launching a new and controversial phase in this, and it may be some years before results become clear and further lessons may be learned. Nevertheless there are points to ponder in its recent reformations, and certainly lessons from its earlier advances.

In all of what follows, the authors draw primarily on just one source: an interview with architect Hans Ornhall. He has been involved in most all of the recent program of rationalization, but is disturbed about (and no longer involved with) the final path chosen. He emphasizes that his view may be considered one-sided. His concerns may be overly represented in this review; the authorities now implementing the final regulatory reforms were not interviewed. Building product manufacturers and a senior building scientist were consulted, however, and appeared to support the following gleanings from the Ornhall interview:

Background: A uniform national approach to building regulation: Rationalization of building regulation was pushed forward in Sweden with the institution of a single national building code, in 1947. This was not a model for voluntary adoption, but a code, supplanting the diverse local by-laws and their various interpretations. It also differed from the "model" codes of Canada and elsewhere in its comprehensive coverage: one book encompassed all the building processes, soon including prefabrication, house manufacturing, industrialized systems, construction safety standards in the factory and on the site, and building operations. In much of this the code writers attempted to stress performance requirements or bases, and worked with their colleagues in the UK and Canada to this end.

The "one book" code did not, however, contain much prescriptive detail on housing

construction, whether traditional site constructions or the more factory-based systems. The detailed code task, in effect, became embodied in the state loan approval process, with its separate code and complement of standards or proprietary system approvals. Since housing production was financed by state loans, the operative code was this detailed loan approval process rather than the more general national code. Nevertheless both had to be honoured, requiring two approvals and two enforcement responsibilities.

(Despite this awkwardness, the uniform national approach appeared to be coupled well with an openness to performance and innovation: A remarkable number of building product advances came from Sweden to Canada and the USA in recent decades.)

Toward one approval process under a general performance umbrella: The recent steps to rationalize, well underway by the middle 1980's, were toward two goals: (1) to put the national code and the loan approval process together and let one approval do the job; (2) let the Building Law itself be written only in general performance terms, but complement it with a "deemed-to-satisfy" Companion Code showing proven example practices in usable and enforceable detail.

The Building Law was prepared, in its new general performance terminology in 1986. The Companion Code was more or less ready in 1987, but was held back for revisions in a further emphasis on change to facilitate innovation, a change toward "deregulation".

Deregulation: A consensus to try a substantial degree of deregulation of the building process appears to have been established by 1987, toward the final stages of introducing the performance law/companion code approach. Of course, deregulation fits comfortably under the umbrella of the generalized performance type of building regulation, which simply states, in effect, "thou shalt build safe and durable buildings". The new movement to deregulation has affected mainly the companion code and its application:

- 1) The new companion code was held back and reworked, stripping it of much of its detail such as requirements for minimum room size and for spatial dimensions for wheelchair access to facilities. (Fire safety requirements, however, remain explicit and conservative, and more or less performance-based as before.)
- 2) The one code became several sectoral codes, e.g. one for restaurants with emphasis

on hygiene, one for hospitals, another for schools....

- 3) The building developer/owner takes final responsibility for the building; professional consultants must be used for the design.
- 4) Design approval is once again relegated to the individual municipal authority, as in the 1940s.

The push for deregulation, slipped quickly into and over the drive for a more performance-based approach to regulation, appears to pose a return to old problems exacerbated by more complex demands on building performance. The Swedish idea of a uniform national level of at least safety, accessibility and energy performance appears to be weakened or made less easily enforceable. The diverse municipal authorities now must increase in number and in expertise, having little guidance or backup from the code generalities. Theoretically, at least, they can reject a system or a building design almost on whimsy. (It is said that one of the largest of the house manufacturers now states that it cannot be sure of further approvals even on its ongoing projects, let alone in further municipalities.)

The next few years will reveal the degree of success of the new combination of deregulation and the generalized expression of performance intent. The lesson will be valuable, in that the mood for favouring deregulation, to foster market-driven innovation, is not limited to Sweden. It seems to be in conflict with the environmentally-driven need for rapid change - intelligent change - in our building stock, as discussed in the final section. On the other hand, Sweden is retaining its national "energy budget" approach to explicit performance requirements for whole buildings, and this should serve as a powerful tool in the hands of competent designers and authorities.

4.7 Norway

Norwegian Building Regulations: The Norwegian equivalent to the NBC is Byggeforskrift 1987. (Building Regulations 1987). These regulations are enacted under the authority of The Planning and Building Act of June 14, 1985. In this review, the original Act was not examined, however; only the English translation of 1987 Building Regulations.

A cursory examination of the Regulations gives the impression of a neat and simple body of

regulations, with considerably less detail than is the custom in North American codes. The regulations are not only much briefer than these codes but much more simply written. This is in spite of the fact that the scope of the regulations appears to be greater than the NBC, covering subjects such as farm buildings, fall-out shelters and lumber storage yards in addition to usual code requirements.

A closer examination of the Norwegian regulations however, illustrate a number of important differences between it and the NBC that allows much of the detail to be deleted.

Exercise of Arbitrary Authorities: Throughout the regulations, frequent references are made to arbitrary rulings that can be exercised by the administrators of the regulations (i.e. the Building Council). This is done without providing specific direction regarding the basis on which such rulings are made. Statements such as, "The Building Council may require the installation of hydraulic hose reels and portable fire extinguishers", or "The Building Council may require the installation of fire alarm systems" are typical of this arbitrary authority. In past years similar arbitrary authority was implied throughout the NBC (although not on such a broad basis). It was considered to be improper, however, to give this arbitrary power without describing the basis on which decisions are to be made. This resulted in similar requirements being removed from the NBC. While this arbitrary decision making power allows briefer and simpler building regulations, it can be misused.

Many of the Norwegian regulations are stated in non-verifiable performance terms. These include statements such as:

"The designs and construction of lifts shall be adequate for the load and function of the lift", or

"Balconies, terraces, etc., shall have balustrades or other arrangements which prevents people from falling off".

While this style of performance writing certainly allows for a considerable reduction in the number of technical requirements, the resulting requirements would appear to be unenforceable. It may well be that there are unstated deemed-to-satisfy standards covering these areas that may be automatically invoked. There is a general statement, for example, that "The technical requirements of the Planning and Building Act, and the requirements of the building regulations are deemed-to-be-satisfied if methods, materials and construction are

carried out in accordance with the Norwegian Standard." Presumably if a deemed-to-satisfy standard is available it can be used, but there is no indication in most of the text where such general statements occur, that any particular standard is to be used.

In these non-verifiable requirements, therefore, there appears to be no real control unless this is taken care of through the customs and practices of the design and enforcement professions.

National Approval: The National Office of Building Technology and Administration, the designated approvals and controls authority, appears to have been given wide ranging authority under the regulations. Under the regulations, "Factory-made elements for buildings, including elements for agricultural buildings, shall be manufactured in accordance with approved construction systems". (The regulations further state that the elements made to Norwegian Standards are not required to have central approval.) It would seem, therefore, that unless a product standard is available, all building materials have to be approved, but the conditions of approval are not stated.

Further, "industrially produced concrete building products shall be produced by an approved manufacturer." This requirement also appears to place additional arbitrary power in the hands of the approval authority. In addition "all unclassified plastic building materials shall be approved in relation to fire resistant properties." By allowing the approvals authority such latitude, much of the detail now in NBC would be no longer necessary.

A Mix of Prescriptive and Performance Requirements: Although many Norwegian building regulations are written in apparently non-verifiable language, there are many that are not. The structural fire protection requirements, for example, appear in verifiable terms much like those in the NBC. (although considerably briefer). Requirements for room heights and volumes, and acoustical requirements also appear in verifiable terms and in much more detail in some aspects than in the NBC.

While the simplicity of the presentation of the requirements in the Norwegian Regulations have a certain appeal, it would seem to raise a number of enforcement problems in the Canadian context. Whether or not approaches taken to simplify the Norwegian requirements would lead to legal challenges in this country is not known.

Having said this, however, a close review of the Norwegian Building Regulations by

Canadian code writers would certainly appear justified. In particular, their approach in specifying structural fire protection seems worthy of further examination as a procedure that appears to give more flexibility than in the NBC while at the same time providing greater simplicity.

Structural Requirements: The structural requirements in the Regulations are based on a concept of probability of failure, as well as seriousness of the failure should it occur. While the regulations do not state specifically that buildings are to be designed in conformance with accepted design standards, this is presumed to be so.

Although this seems like a logical approach to establishing allowable design stresses, the assumed failure probabilities determined on the basis of current data would appear to be largely guesswork. In effect they appear to be another approach in developing the importance factors used in the NBC. No rule-of-thumb construction requirements are provided in the regulations to cover simple structures as is done in Part 9 of the NBC, although it is possible other deemed-to-satisfy standards exist for that purpose.

General Observations: In summary, then, the Norwegian Building regulations seem to be a mixture of performance and prescriptive requirements, although in this case weighted on the side of the former. The performance requirements appear in both verifiable and non-verifiable forms, and it is presumed that Norwegian deemed-to-satisfy standards exist to complement the non-verifiable performance requirements.

While the Norwegian Building Regulations may appear somewhat inadequate in the Canadian context, they may well be most appropriate in the Norwegian context, and be quite sufficient to accomplish the same objectives there as the more detailed NBC attempts to accomplish in Canada. Limited interviews with both component manufacturers and building researchers (the latter in university and public agencies) reinforced the general notion of a distinctive factor at work in Norway: a partnership attitude among building practitioners and authorities, with respect for technical research on methods and solutions - with or without their formal codification.

5. EUROPE: HARMONIZATION OF REGULATIONS FOR TRADE IN GOODS AND SERVICES

Summary:

The move towards international harmonization of standards began with the post-war efforts of the International Organization for Standardization (ISO).

The UN Economic Commission for Europe (ECE) decided in 1980 to produce "A Compendium of Model Provisions for Building Regulations". Its purpose was also to encourage harmonization. The Compendium, consisting of verifiable performance requirements, was issued in part four years later, and is still far from complete.

In 1986, members of the European Economic Community (EC) agreed to remove all trade barriers to goods and services by 1992. A "Construction Products Directive", issued in 1988 and coming into effect in 1991 outlines instructions to member states to meet the agreement. This has been followed by various interpretative documents elaborating on the directive. Unlike the ISO and ECE documents, the EC directive is binding on all member states.

In future, products will have to bear the "CE" mark to show compliance with the standards issued by the EC European Committee for Standardization (CEN, or in the electrical field, CENELEC), or meet the product evaluation requirements of the European Organization for Technical Approvals (EOTA).

Other directives affecting building construction have also been issued covering both goods and services, including design services.

The various directives, while not directly applying to national building regulations, will, nevertheless, impinge on them, so that such regulations have to be revised to reflect the spirit of the Directive.

5.1 The Changing European Scene

In 1992 the remaining trade barriers between many European states are destined to disappear, and there will be a virtually unrestricted flow of goods and services between these nations. This agreement among the twelve countries making up the European Economic Community (EC) has set in motion a remarkable chain of events that will convert this agreement into a practical reality. These events, while affecting directly design, testing and product standards, should also have an indirect effect on building regulations as well.

Events Prior to the EC Agreement: Groundwork for the harmonization of building standards in Europe began in 1947 with the creation of the first Technical Committee in the building field, organized under the auspices of the International Organization for Standardization (ISO). In the years following, many other organizations were also active in the harmonization process in various fields of interest.

The harmonization of building regulations, as well as building standards, was perceived as one of a number of measures needed to facilitate international trade in the building field. Pressure to harmonize such regulations came principally from the manufacturing industry as a means to encourage greater industrialization through mass production of building products [58].

When building construction was an indigenous industry relying on local materials, local differences in building regulations were not considered to be a significant barrier to trade. The growth of the building industry in the postwar period, however, changed this attitude, and such differences were seen to represent a significant trade barrier.

Model Building Regulations: Working under the auspices of the United Nation's Economic Commission for Europe (ECE), the Working Party of the Committee on Housing, Building and Planning decided in 1980 to produce a tangible instrument to encourage the harmonization of building regulations. It was decided that the most effective way to bring this process about was to develop model requirements based on performance rather than prescriptive requirements. It was considered to be impractical to attempt to develop a voluntary international consensus on the basis of prescriptive requirements, due to their complexity.

In 1984, the Working Party published the first four chapters of the ECE "Compendium of Model Provisions for Building Regulations [59]. Although expressed as performance requirements, these were also put in terms amenable to verification. This, it may be noted, is in contrast to the non-specific terminology proposed for the New Zealand code and in the Building Regulations for England and Wales discussed earlier.

While ostensibly based on the Nordic hierarchial model, the Working Party condensed the

first three stages of the model into a single stage. The fourth and fifth stages (verification and deemed-to satisfy solutions), which are necessary for the practical application of performance requirements, were not produced. These were considered to be the responsibility of other agencies.

The Compendium may be considered as a sort of catalogue of performance requirements from which legislating bodies can select elements for inclusions in their own code if they are found to be appropriate.

Two additional chapters have been recently added to the original four, and it is intended that the Compendium will eventually have about fifteen chapters in all. It is far from complete, and so far only applies to housing. (Further information on the development of the Compendium can be found in Reference 58.)

At this stage of its development, it is difficult to assess the potential influence of the Compendium on the European harmonization process. A casual examination of the types of performance requirements contained in it indicates that it probably will not have much of an influence on Canadian codes, since many of the requirements are expressed in terms that seem to be impractical to measure or police.

5.2 The Effect of Free Trade on Building Regulations and Standards

The Single European Act, agreed to in principle in 1986 by the EC, had as its objective the removal of trade barriers, including non-tariff barriers, for all goods and services by December 31, 1992. This Act led to the chain of events mentioned earlier for harmonizing the requirements for goods and services within the EC. In effect, it greatly accelerated the process that was already taking place on a voluntary basis.

To accomplish the objectives of the Act, a series of Council "Directives" have been issued by the EC on a sector by sector basis. These contain the "essential requirements for health protection, safety, the environment, and industrial policy." Once adopted by the member states they become binding on those states.

Although a number of such directives have been issued affecting the building industry, the most significant is the "Construction Products Directive" issued in late 1988 which will

become effective throughout the EC on June 27, 1991 [60]. This instrument provides the essential instructions to member states for the changes required to meet the objectives of the agreement. The Directive in turn is followed by a series of "interpretive documents" elaborating on the generalities of the Directive. These function as regulatory reference points for the preparation of technical standards to be developed later.

Under the agreement, the only products that can be placed on the market in any member country are those that satisfy the requirements laid down in the Directive and its interpretive documents. These will have a profound effect not only on existing product standards, but on design and testing standards as well. Since products are introduced from time to time for which there is no existing standards, it also affects the product evaluation machinery in each state.

Under the agreement, most products will be identified with a "CE" mark indicating compliance with the Directive. This can be earned by showing compliance with an approved standard, or through an approved evaluation and testing procedure.

Standards: The European Committee for Standardization (CEN), established in 1961 as a regional standards body to serve the EC, will be responsible for actually producing the necessary standards. Its members are the national standards agencies for the 12 EC countries and the 6 member European Free Trade Association (EFTA). (The latter are non-member countries who often enter into agreements with the EC). A similar committee, the Committee for Electrotechnical Standardization (CENELEC) serves the electrical industry.

These agencies act separately from the ISO, previously noted as having pioneered the march towards standards harmonization many years earlier. The latter is open to all, with a current membership of 91 countries. Its mandate is to create a worldwide forum for the preparation of standards. (Although no ISO standards are referenced in the NBC, there is little doubt that there has been some influence on Canadian standards through common memberships.) Under the General Agreement on Tariffs and Trade (GATT), EC countries have agreed to use ISO standards as the basis for CEN (OR CENELEC) standards where appropriate [61].

Product Evaluation: Most European countries with national building regulations also have national evaluation and approvals services. Unless the rules and procedures of such agencies are also harmonized, products not manufactured to recognized standards could be subject to

unfair restrictions. This is a complex problem to solve because of the large number of products, and the intricacies of the different approval systems.

Nevertheless, over the years a number of bilateral and regional agreements have been made for the international recognition of products within the Nordic countries as well as within the EC. This has occurred largely without common principles being formalized regarding testing, inspection or control rules.

Of particular interest in such arrangements has been the European Union of Agreement Techniques in Construction (UEAtc). Like the CEN Standards body, UEAtc is an association representing both the EC and EFTA. This organization, formed in 1960, is a voluntary association to foster international recognition of technical approvals, and operates outside of the EC umbrella. UEAtc issues guidelines that provide a common technical basis for its members on which to issue technical approvals.

Under the Construction Products Directive, the concept of a European Technical Approval system was conceived whereby approvals issued by a designated body in one country would be honoured in all member countries. Thus was born the European Organization for Technical Approvals (EOTA) representing the 12 states of the EC. It will replace the UEAtc in the EC countries [62].

The relationship between UEAtc and the EOTA has not yet been agreed upon. It would appear reasonable to assume that UEAtc will have to be melded in some way with the EOTA to take advantage of the existing infrastructures and expertise.

5.3 Effect of the Directive on Domestic Building Regulations

It seems obvious that national building regulations will indeed be affected by the new European agreement, albeit not directly. It would seem that to avoid contravening the international agreement, recognition will have to be made either administratively or through direct references to the new CEN standards as they develop. The regulations will presumably also have to recognize EOTA approvals where there are no approved standards. Whether national standards will be withdrawn as the CEN standards are introduced is not known, but this would seem likely.

Since the agreement does not control directly local building regulations, it would seem to make little legal difference whether such requirements are expressed in performance or prescriptive terms, provided the conditions laid down in the Construction Products Directive are honoured. If the regulations could be expressed in verifiable performance terms, and the CEN standards are referenced both for deemed-to-satisfy solutions and for verification purposes, this could assist in avoiding potential conflicts between building regulations and the agreement. If, on the other hand, the objective of new building legislation is for the deregulation of the building process, then performance requirements can also be used to this end, particularly if they are written in non-verifiable terms, which is so easy to do. This can give the appearance of requirements, but not the substance.

It should also be noted that other EC "directives", either issued or planned which could impinge on building regulations to a lesser degree cover subjects such as mutual recognition of professional qualifications, mutual recognition of architectural qualifications, product safety, machinery safety, gas appliances, health and safety in the workplace, and health and safety on construction sites [63].

The enormity of the work involved in producing the required standards can only be imagined, and it has been questioned by some as to whether or not it can be accomplished in the given time allocation. There appears to be no doubt, however, that there is sufficient political will to bring the project to a successful conclusion.

6. LOOKING AHEAD: IMPROVING THE REGULATORY PROCESS TO HANDLE RAPID CHANGE

It is said that change is now the only constant; society can scarcely turn back from its path of extremely rapid change. The building sector faces pervasive change, in how society transforms and uses its existing building stock as well as in new design and construction. Energy usage must be reduced throughout the sector, to extend finite resources and "buy time" to bring in renewable or essentially infinite resources. Fossil fuel usage must especially be reduced for that reason and to curtail carbon dioxide production and its greenhouse effect. Of course, none of this may be accomplished adequately unless the population explosion itself is dampened effectively, and soon.

6.1 Innovation in the building materials themselves

Improvements in building construction and in extensive retrofit of the existing stock will require innovative interventions at most points in the process. As one prime example, the resources and energy consumed in the production of building materials must become a primary factor in choosing and developing them. Concrete, for example, not only requires large inputs of energy in cement manufacture, with attendant release from fuel combustion, but the chemical reaction itself releases carbon dioxide. Other inorganic materials are also energy intensive in basic production and forming. On the other hand, organic high polymers (wood, plastics) can be produced from biomass with little energy usage, and can be used as whole components or simply as binders in fibre or mineral composites.

Clearly, the building regulatory process will have to allow an unprecedented sweep of innovation and yet retain a safe standard. The shift to organic materials, which has been accelerating for three decades, will increase the need for the whole-building approach to fire safety, for example. (That may only be implemented logically, in safety performance terms, with computer-based modelling, design, regulation and enforcement. The Canada-Australia work to that end was discussed earlier.) Although the job is becoming more complex, it seems clear that society must apply more and smarter regulatory intervention, not less, to accommodate and control the building changes that must be made.

There are many other constraints and needs which will demand building innovation and compatible regulation: the need to conserve potable water, timber resources, and arable land, and to reduce wastage and pollution, are some further examples. It is instructive to consider one need, energy conservation, in somewhat more detail to explore its accommodation within the regulatory process.

6.2 Energy efficiency demands and performance regulation

A primary target in preserving dwindling finite resources is in the field of energy consumption, since this has a double barrelled effect on pollution reduction and resource conservation. Since many aspects of energy conservation have off-setting financial benefits, and may even provide a reasonable return on invested capital, they are the least likely to raise major objections with either the business community or the general public. In any case, energy conservation has to be accelerated.

The oil crises in the early 1970s and currently have demonstrated the vulnerability of industrialized nations to the supply of Middle East oil. Even though large reserves may still exist, it would appear to be in the best long term interests to reduce dependency on oil. Increased emphasis will have to be made to reduce the use of energy in all oil dependent countries, while converting to alternative energy sources. Such programs inevitably involve building regulations.

A preview of the form that such programs may take was provided following the first oil crisis. Programs were launched both to reduce energy use in buildings and to promote alternatives to oil. These "off oil" objectives will no doubt be the target of new and stronger legislation and incentives.

The earlier oil crisis led to a few incentive programs to encourage upgrading of insulation and "off oil" measures in existing houses. Those programs, and the impact of higher fuel prices (and perhaps the example of improved heating efficiency in new houses) led to widespread activity in "retrofit" insulating and airtightening in this vast sector.

For new house construction, model energy requirements were developed by the ACNBC [4], but these were enacted by Quebec alone. Other provinces either introduced their own thermal resistance requirements for house envelopes directly in their provincial codes, or took no

legislative action. Other initiatives became influential, especially the "R2000" program initiated by government. The net result of these various influences was a marked increase in insulation and airtightness in new house construction and many existing houses.

Although energy conservation requirements for houses in the past have emphasized only the thermal resistance performance of envelope components, it is likely that future requirements will emphasize whole-building "energy budget" performance requirements. By specifying maximum heat loss in terms of a unit floor area (ie. energy budgets) greater design flexibility is possible. (This was noted in the discussion on Sweden.) Such a budget approach can favour large buildings, however, which can more easily attain a low energy consumption per unit area while actually increasing the total consumption. (R2000 houses can be deceptive in that manner.) Future regulations should tend to state building performance on a per-occupant or per-user basis. Again, such complete design, codification and enforcement becomes more practicable with computers.

It is clear that future building regulations will have to address existing as well as new buildings. Since new construction affects less than three per cent of the building stock, it is obvious that regulations applying to new buildings only will have very limited effectiveness, as was noted in an earlier section.

6.3 Air Quality: energy conservation requires still further interventions

Where ventilation rates are restricted to conserve energy, other problems may arise which have to be addressed through additional building legislation.

Reducing ventilation not only increases the indoor relative humidity and its attendant moisture problems, but also the concentrations of indoor air pollutants. These may include radon or other gases from the soil; pollutants from normal indoor activities (cleaning, cooking, heating, decorating, hobbies); and those emanating from construction materials, finishes and household furnishings.

The need for mechanical ventilation in modern tight houses has now been recognized in building codes, as well as the need to restrict the entry of radon. If regulations for maximum air leakage are introduced, particularly for existing buildings, parallel requirements will also have to consider augmenting ventilation or other counter measures to protect the health of the

occupants.

The evaluation of new and old products for use in tightly constructed houses will also have to consider their potential health hazard arising from volatile constituents. In the past, when houses were fairly leaky, and the constituents in most products fairly well known, (or the ill effects simply not known), this appeared to present few problems. With tightened houses, however, and the burgeoning variety of chemicals currently in use, as well as increasing awareness of possible sensitivities, additional restrictions may have to be imposed on their use either through building regulations or some other legal instrument.

Computer or no computer, it can be seen that many of these complex interrelationships can only be managed by manufacturers, designers builders, and regulatory agencies as the building science knowledge base is developed. No party can move farther or faster than permitted by the knowledge base. From every party's point of view, progress will be facilitated by increasing the efforts to rationalize the design, control and production of buildings in performance terms, and where practicable to express the requirements accordingly.

6.4 Conclusions: The need to introduce performance requirements constructively and knowledgably

While there are obvious advantages for all code users in knowing the objectives of each requirement, and in expressing requirements in terms that facilitate innovation, this can only be accomplished to the extent that appropriate knowledge is available. The temptation to make intuitive changes beyond this limit should be resisted if these can place occupants at additional risk or lead to unnecessary cost increases.

The following conclusions of this study, address eighteen separate issues:

1. **Are regulations too restrictive?** No matter what regulatory or approval system is established it will present some degree of restrictions to innovation. (If this were not the case, there would be no need to have any type of building regulations). The question to be answered, therefore, is the degree of restriction justified in terms of the performance objectives.
2. **Does the NBC restrict innovations?** There is little evidence that the prevalence of prescriptive requirements in the NBC has in itself seriously inhibited the introduction of innovations in construction.
3. **Are drastic code changes warranted?** While certain examples have been brought to light of perceived undue restrictions to new products, where a "performance approach" in the NBC may have facilitated the evaluation process, it is doubtful if these examples would warrant a revamping of the current approach.
4. **Why are other countries changing?** The literature indicates that in a number of countries where a complete overhaul of the building code was undertaken (NZ, UK, Australia) it came about as a result of general dissatisfaction among code users. There does not appear to be the same groundswell of criticism of the National Building Code.
5. **What are the effects of performance codes?** While there has been a move toward a conversion to performance building codes in a number of countries, it is premature

to assess the effect of this conversion on the construction industries in those countries.

6. **Are codes unduly blamed for restrictions?** When a proponent faces restrictions, there may be a tendency to blame "the building code" regardless of the real cause for the restriction. Whether the restriction is due to the approval process, to the enabling provincial legislation or to the lack of experience of the administrator makes little difference to the proponent. All can be perceived to be due to "the building code".
7. **Why train building officials?** The important role played by local building officials in facilitating or restricting innovations requires that such positions be filled by adequately trained personnel to encourage the judicious application of building code requirements.
8. **Are performance codes attainable?** While the development of a verifiable performance based code to supplant the current NBC is not a practical short term objective, the development of verifiable performance requirements could be pursued as a long term objective of the ACNBC. If such an objective were made known to the technical committees, they would be able to develop priority ratings consistent with available resources. Since standards form an integral part of building codes, these comments obviously apply to all codes and standards writing committees.
9. **What limits their development?** Verifiable performance requirements, if they are to be reasonable and realistic, can only be established to the extent that there is sufficient knowledge to do so. Arbitrary performance numbers without a knowledge foundation to justify them can lead to unnecessary costs or constraints if they are too conservative, or a decrease in safety if they are not conservative enough.
10. **Are non-verifiable performance codes practical?** The conversion of the current NBC requirements to a series of non-verifiable performance generalities that depend exclusively on other documents for deemed-to-satisfy solutions (similar to the UK and NZ approaches) serves no practical purpose, and may in fact make the NBC unenforceable. As was shown, this has already been tried in Canada in the 1965 NBC with little success.

11. **How should performance requirements be introduced?** Where performance requirements are introduced, it is important that there be as little disruption as possible to code users. "Deemed-to-satisfy" solutions are therefore generally retained from existing requirements as an option to satisfy such performance levels. Practical considerations to facilitate code implementation dictate the need for "deemed-to-satisfy" solutions whenever performance requirements are used.
12. **How should codes be written?** Whatever form a requirement takes, it is obviously advantageous to the code user that it be expressed clearly, allow alternative solutions, and satisfy its objective in the most cost effective manner.
13. **Can other aids be found to help code users?** The evaluation of alternatives or equivalencies can be assisted by clear statements that explain the objectives of individual NBC requirements. While many such areas are currently covered in the appendix to the code and in the commentaries, these are not complete nor is there a consistency in format that allows an easy match to be made between the requirement objective and the requirement.
14. **What should be in codes and what should be in standards?** There appears to be no consistent policy regarding the type of material to be included in the National Building Code and the material that should be in referenced standards. It would be useful for writers of codes and standards if the advantages and disadvantages of having detailed requirements in the code or in separate standards were determined in the light of the use of the code by designers or builders as well building officials. Where there is little advantage of retaining detailed requirements in the code, appropriate reference standards can be used. Where the requirements are considered to be more appropriate as code requirements, there is little justification to require the code user to refer to another document. If the standards writing agencies are made aware of such policies they would be able take appropriate action.
15. **Are code writing and product evaluation related?** The CCMC evaluation service and IRC's Codes Section have complementary goals in defining the objectives of code requirements. The former must know these in order to determine if a product conforms to the code while the latter requires this knowledge to be able to draft the

code requirements. Both can learn from the experiences of the other and thereby facilitate the move towards verifiable performance requirements.

16. **How can the NBC be improved?** While the NBC has not been demonstrated to be unduly restrictive to innovations, there are obvious areas where improvements can be made in the manner in which requirements are expressed to improve its comprehension by users. (Australia is currently examining its code in this light.)
17. **What is the most important factor affecting innovations?** The natural path for the introduction of innovations is by an evaluation process rather than by way of code recognition. Some innovators, however, are frustrated with the length of time required for evaluation, and with what they perceive as unnecessary demands for additional product testing. Therefore, the improvement and further development of a process that is perceived by the innovator as being accessible, fair and open to appeal, has obvious inherent advantages. **The evaluation component indeed appears to be the key ingredient in the regulatory process facilitating or inhibiting innovations.** The manner in which this function is carried out can have an effect on innovations to a far greater degree than the manner in which a code requirement is expressed, particularly in the light of the equivalency requirements in Section 2.5 of the NBC.
18. **What about administrative costs?** Several countries have become concerned about the cost of administering building regulations, and are exploring alternative arrangements, including privatization. This subject is also under review by a number of provinces. Information on such costs does not appear to be readily available to allow cost comparisons of alternative administrative systems to be made. This is an area requiring further study.

6.5 Concluding Remarks

The question that initiated this project is whether or not Canadian Building Codes are too restrictive. In retrospect, this question might be considered naive. There can logically be only one answer: of course Canadian building codes are too restrictive, just like all other building codes. Unless every requirement is written as a perfect balance between costs and benefits there are bound to be requirements that are too restrictive, just as there are requirements that are not restrictive enough.

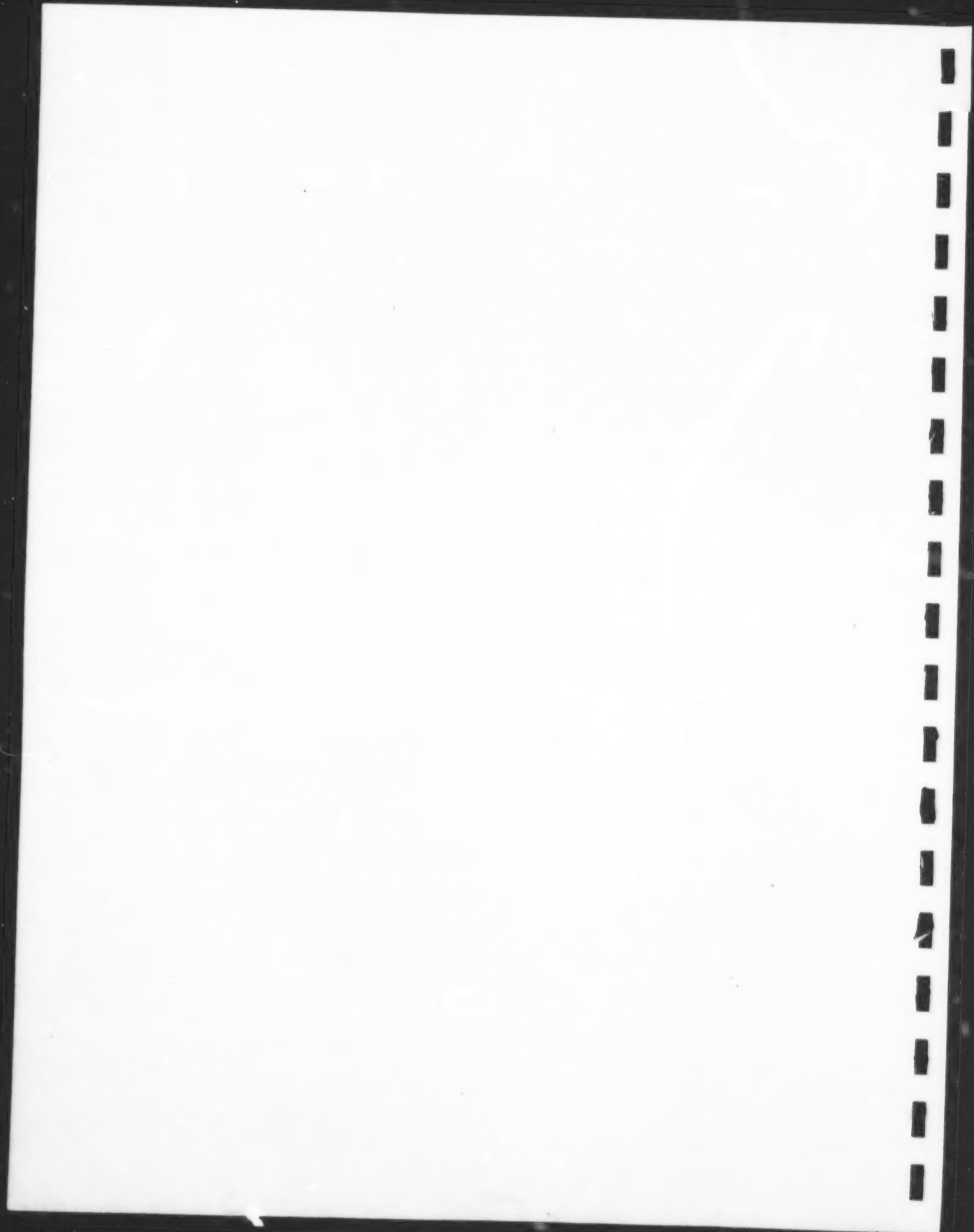
All codes have to be fine-tuned continually as more knowledge and insight develops. This is an on-going process that will never be completed in a world that is constantly changing, technically, economically and socially. The large number of changes that are processed with each edition of the NBC is testimony to the evolutionary nature of building regulations.

The corollary to the first question is whether a more performance based code would facilitate innovation. Again the answer must be an unequivocal yes, **provided the performance levels are stated in verifiable terms, and the levels are realistic.** This, however, can only be achieved when there is sufficient knowledge and insight to make it possible, and when all parties use that knowledge.

It would be a mistake to assume that Canadian building codes (or the product evaluation process) have gone as far as they can in developing verifiable performance requirements with all available knowledge. Further advances do not have to await additional research. The available knowledge base is a huge resource that can be constantly mined for knowledge to apply to building regulations to make them more cost effective. Indeed this process is on-going and helps to account for the constantly changing requirements of both sorts: performance requirements and deemed-to-comply solutions.

Creating new knowledge through theoretical or applied research must also continue, however, in order to fill known knowledge gaps and to improve existing data. The growth in computer modelling as an effective means to rationalize code requirements clearly depends on such knowledge.

While there are clearly areas for improvement that are achievable, no breakthrough solutions should be expected to simplify the complicated process of regulating building construction. If society wishes to maintain **effective** control of building construction to protect its citizens, codes will continue to be complex although significant steps can be taken to make them clearer and to maintain a continuing evolutionary improvement, motivated by both market demands and user expectations.



References

1. "Working With the Performance Approach to Buildings", CIB Report, Publication 64, January, 1982.
2. Hansen, A. T., "The Regulation of Building Construction". Canadian Building Digest No. 237. National Research Council of Canada, Ottawa, March, 1985.
3. National Building Code of Canada, 1990. National Research Council of Canada, Ottawa, 1990.
4. Measures for Energy Conservation in New Buildings. National Research Council of Canada, Ottawa, 1983.
5. Supplement to the National Building Code of Canada, 1990. National Research Council of Canada, Ottawa, 1990.
6. Hansen, A. T. "Applying Building Codes to Existing Buildings". Canadian Building Digest No. 230, National Research Council, Ottawa, January, 1984.
7. National Fire Code of Canada 1990. National Research Council of Canada, Ottawa, 1990.
8. Canadian Plumbing Code, 1990. National Research Council of Canada, Ottawa, 1990.
9. Canadian Electrical Code - C22.1. Canadian Standards Association, Rexdale, Ontario, 1986.
10. Residential Standards, 1965. National Research Council of Canada, Ottawa, 1965.
11. Guideline F. "The Preparation of CSA Standards". Canadian Standards Association, Rexdale, Ontario, May, 1987.
12. Administrative Requirements for Use With the National Building Code, 1985. Associate Committee With National Building Code, NRCC 22565, National Research Council, Ottawa, 1985.
13. Building Action Newsletter, Ontario Buildings Branch. Ministry of Housing, Toronto, February, 1990.
14. Dunn, R. H., "A Summary With Key Observations of The Provincial and Territorial Inspection Services Report dated November, 1987". Report prepared for the Canadian Construction Research Board, National Research Council of Canada, Ottawa, 24 January 1989.
15. "Discussion Paper on Regulations related to Housing Affordability, Choice, Quality and Innovation". Prepared by Energy Pathways Inc. for Canada Mortgage and Housing Corporation, Ottawa, December 1989.

16. Rostenne, Jacques, "Technology Transfer and Innovation in the Canadian Residential Construction Industry". Report prepared for CMHC by James F. Hickling Management Consultants, Ottawa, January, 1989.
17. "Directory of Construction Product Standards and Acceptance Programs". Canadian Construction Materials Centre, National Research Council of Canada, NRCC 31380, Ottawa, June, 1990.
18. CCMC Evaluation Listings, Vol. 1. National Research Council of Canada, Ottawa, December, 1989.
19. "Feasibility Study for an International Directory of Building Product Evaluations". Study prepared for CCMC by Norm Hagan and Associates Inc., Ottawa, March, 1990.
20. Hansen, A. T., "Trussed Rafters for Houses". NRC 7532, National Research Council of Canada, Ottawa, 1963.
21. "Load Test for Wood Roof Trusses for Houses and Small Buildings". CSA S307-M1980, Canadian Standards Association, Rexdale, Ontario, 1980.
22. Legget, R. F. and Hutcheon, N. B., "Performance Testing Standards for Buildings". Canadian Building Digest No. 210, National Research Council of Canada, Ottawa, Dec. 1979.
23. "Windows", CAN3-A440-M84. Canadian Standards Association, Rexdale, Ontario, 1984.
24. "Construction Sheathing", CAN/CSA-0325.0-88. Canadian Standards Association, Rexdale, Ontario, 1988.
25. "Structural Requirements for Mobile Homes", CAN/CSA-Z240.2.1-M86. Canadian Standards Association, Rexdale, Ontario, 1986.
26. Mehaffey, J. R. and Harmathy, T.Z., "Thermal Response of Compartment Boundaries to Fire". Fire Science Proceedings of the First International Symposium, Gaithersburg, M. D., Oct 9-11, 1985.
27. Harmathy, T. Z. and Mehaffey, J. R., "The Formalized Heat Load Concept and Its Use". Fire Safety Journal 12, 1987.
28. Mehaffey, J. R., "Fire Modelling and Fire Safety Design". Prepared for the International Conference on Municipal Code Administration, Winnipeg, Manitoba, Sept 24-28, 1989.
29. Beck, V. R., "A Cost-Effective Decision-Making Model for Building Fire Safety and Protection". Fire Safety Journal, Vol. 12, No. 2, 1987.

30. Beck, V. R. and Poon, S. L., "Results From a Cost-Effective Decision-Making Model for Building Fire Safety and Protection". *Fire Safety Journal*, Vol.13, No. 2-3, 1988.
31. Yung, D. and Beck, V. R., "A Risk-Cost Assessment Model for Evaluating Fire Risks and Protection Costs in Apartment Buildings". Report from the Institution of Engineers, Australia's Proceedings, International Symposium on Fire Engineering for Building Structures and Safety, Melbourne, NRCC paper No. 31064, November, 1989.
32. Building Code Assessment Model. Report prepared by TROW-IBI, Toronto, Ontario, March, 1990.
33. Arlani, Ali G., "Building Code Assessment Framework". International Conference on Municipal Code Administration, Winnipeg, Manitoba, Sept. 24-28, 1989.
34. McConnaughey, John S. Jr., "An Economic Analysis of Building Code/Impacts: A Suggested Approach". U. S. Dept. of Commerce, National Bureau of Standards, Washington, D. C., 1984.
35. Gomberg, A., Buchbinder, B. and Offensend, F. L., "Evaluating Alternative Strategies for Reducing Residential Fire Losses - The Fire Loss Model". National Bureau of Standards, Washington, D. C., Aug. 1982.
36. Ruegy, Rosalie T. and Fuller, S. K., "A Benefit-Cost model for Residential Fire Sprinkler Systems". National Bureau of Standards, NBS Tech. Note No. 1203, Washington, D. C., Nov. 1984.
37. Budnick, Edward, K., "Estimating Effectiveness of State-of-the-Art Detectors and Automatic Sprinklers on Life Safety in Residential Occupancies". National Bureau of Standards, NBSIR-84-2189, Washington, D. C., Jan. 1984.
38. Hansen, A. T. and Platts, R. E., "Analysis of the Cost-Benefits of Installing Fire Sprinklers in Houses". Prepared for Canada Mortgage and Housing Corporation by Scanada Consultants Limited, Ottawa, June 1989.
39. Hansen, A. T. and Platts, R. E., "The Costs and Benefits of Smoke Alarms in Canadian Houses". Prepared for Canada Mortgage and Housing Corporation by Scanada Consultants Limited, Ottawa, March 1990.
40. Wible, Robert C., "A Unique Look at Building Codes Used Throughout the United States, and the Role That Computerization Can Play in America's Building Regulatory Future". International Conference on Municipal Code Administration, Winnipeg, Manitoba, Sept 24-28, 1989.
41. "Codes - A Much Misunderstood Contraption". *Engineering News Record*, June 1989.

42. Hicks, Harold D. Jr., "Building Codes in the U. S." *Plastics in Building Construction*, Vol. XIII, No. 6, 1989.
43. Gross, James G., "Harmonization of Standards and Regulations: Problems and Opportunities for the United States". *Building Standards*, March/April 1990.
44. "Model Code Implementation Study for GSA Underway". *Building Sciences*, (National Institute of Building Sciences), Vol. 13, March 1989.
45. ACNBC Policies and Procedures 1985. Associate Committee on the National Building Code, National Research Council of Canada, NRCC 24378, Ottawa, 1985.
46. "Operation Breakthrough". U. S. Dept. of Housing and Urban Development, Washington, D. C., 1972.
47. "Appendix Chapter 12, Division III, Requirements for Radon Control for Group R, Division 3 Occupancies". Preliminary Report of the Indoor Air Quality Code Development Committee, International Conference of Building Officials, *Building Standards*, March-April, 1990.
48. Heitz, Michael J. - AIA and Gellenbeck, R. E., Private Sector Inspection Alternatives to Sustain Services During "Boom" and "Bust" Construction Cycles". *Building Standards* (Pub. by ICBO), Jan-Feb. 1990.
49. The Building Standard Law of Japan, published by the Building Centre of Japan, Tokyo, July 1986.
50. Introduction to Building Standard Law, Ministry of Construction, Tokyo, 1986.
51. "A Quick Look at Housing in Japan". The Building Centre of Japan, March 1985.
52. Smith, Paul R., "The Development of a National Building Code in Australia". Presented at the International Conference on Municipal Code Administration, Winnipeg, Manitoba, September, 1989.
53. Blackmire, James M., "The Development of the Building Code of Australia - The Project Management of a Complex Code". Paper presented at the International Conference on Municipal Code Administration Building Safety and the Computer, Winnipeg, Manitoba, Sept 24-28, 1989.
54. Tippet, Helen, "Building Control Reform in New Zealand". Social and Economic Implementation, CIB W55/W65 International Symposium on Building Economics and Construction Management, University of Technology, Sydney, Australia, March 1990.
55. Reform of Building Controls. Report of the Building Industry Commission to the Minister of International Affairs, ISBN 0-477-01545-X, Wellington, N. Z., January, 1990.

56. "Escape Clauses". Building, 11 May 1990.
57. Elder, A. J., "Guide to the Building Regulations 1985 for England and Wales". The Architectural Press Ltd., London, 1986.
58. "International Harmonization of Building Regulations in the ECE Region", Economic Commission for Europe L=CE/HBP/62. Report prepared by the ECE Secretariat for the Working Party on Building of the ECE Committee on Housing, Building and Planning, United Nations, New York, 1987.
59. "ECE Compendium of Model Provisions for Building Regulations", (Economic Commission for Europe), United Nations, New York, 1984.
60. " Council Directive of 21 December 1988 on the Approximation of Laws, Regulations and Administrative Provisions of the Member States Relating to Construction Products". Official Journal of the European Communities, Brussels, 11 February 1989.
61. Davis, Helen, "Standardization in Europe" "A Success Story". ASTM Standardization News, February, 1990.
62. "From UEAtc to EOTA: European Technical Approval on the March", UEAtc Information, July, 1990.
63. Euronews Construction, Issue No. 9, Dept. of the Environment, Construction Directorate, February, 1990.

APPENDIX A

PROVINCIAL BUILDING OFFICIALS' VIEWS

APPENDIX A

Provincial Building Officials' Views

Although the NBC is issued by a federal agency, the regulation of buildings under the Canadian Constitution is a provincial responsibility. The views of provincial regulatory authorities therefore are important in assessing the effectiveness of the NBC and its impact on building innovations.

Accordingly, therefore, contact was made with each of the provincial authorities responsible for building regulations. Seven specific questions were posed requesting their views on the NBC and on the support services provided by provincial agencies to local jurisdictions. All provinces responded to this request. The purpose of this Appendix is to summarize the responses to the specific questions asked.

Question 1: Do you share the view that innovations in construction are being unduly restricted because of regulations:

BC: "I agree with this statement, but would comment that the cause of the restriction to innovation is not solely whether the code is performance or prescriptive, it also has to do with the inherent complexity of the code and the user's knowledge."

Alberta: "I do not share the view that innovation in construction is being unduly restricted because of regulations. We have a good example of assistance to innovation that our building regulations have made in the "oriented Strandboard" success story in Alberta. We were able to approve the use of the product as an equivalent to waferboard and eventually plywood under our code. This established a target market that allowed initial development to proceed and eventually led to outstanding success.

The key was proper planning and having done that, the determination and skill in follow through with the plan. Innovations implemented in a thorough and competent fashion have no problems in succeeding."

Saskatchewan: "I do not share this view as the equivalency provisions of the NBC are provided for the purpose of preventing restriction. I do, however, recognize that the lack of training and imagination, and undue caution on the part of many designers and building officials, result in restriction."

Manitoba: "The National Building Code is essentially prescriptive in nature, in that requirements are mainly defined by describing proven construction and engineering practices for currently used construction systems and mechanical equipment. The advantage of this approach is that it provides designers and builders with a clear picture of what is acceptable. It is also easy for an enforcement official to administer. Although all codes provide for the acceptance of "equivalents", those designers who wish to introduce innovations in construction are faced with a complex task of having to prove that their system performs at least as well as a system described in the Code. This can be a major deterrent to the introduction of new innovations in construction."

Ontario: "This is a very broad question because it deals with regulations in general. If your question pertains to the Ontario Building Code, then our view would be that the question should be restated to ask if innovation is being restricted by the Building Code regulations well before they become unduly restrictive.

Regulations may restrict innovations in construction. Article 9.3.0.1. of the Ontario Building Code permits the use of materials, appliances, systems and equipment not specifically described for building governed by Part 9 under certain conditions, Section 9 of Bill 103, "An Act to revise the Building Code Act", proposes to extend the powers of the chief building official to accept innovations in construction. Section 9 will permit the chief building official to authorize the use of "materials, techniques and systems that are not authorized in the building code" under certain conditions. We feel that, upon the enactment of Bill 103, the Ontario Building Code will not unduly restrict innovations in construction."

Quebec: "Nous partageons ce point de vue, mais ceci est susceptible de varier beaucoup selon la nature du code considéré. Or, la principale mission du ministère du Travail du Québec en est une de sécurité dans le bâtiment. La question qui nous vient dès lors, concerne l'inspection et la vérification: dans quelle mesure pourra-t-on confirmer qu'une norme de performance en sécurité aura été respectée? La sécurité dans des édifices repose actuellement sur la prescription de minima et sur des pratiques reconnues acceptables et ayant fait leurs preuves: l'innovation, parfois, pourra donner cours à de nouvelles approches, qui certes réduiront les coûts, tout en laissant place à une certaine interprétation. Si cela se produit, l'objectif de sécurité qui est nôtre peut en souffrir, à moins que cette innovation fasse l'objet de certification par un organisme reconnu. Or, déjà la plupart des codes ne font-ils par référence à des normes reconnues?"

N.B.: " Unable to answer as regulations are administered by each city, town or municipality."

Nova Scotia: "No, one must be cautious when faced with new or innovative products and/or systems which could have an adverse effect on the quality of building construction. Our province has adopted the National Building Code in 1987 and Part 2 of this Code (equivalents) allows the building official to review the product and its accompanying documentation and ascertain its acceptance.; Such acceptance is usually conditional, short term, or written in such a way that it may be withdrawn, at any time, if later found to be unsatisfactory."

Newfoundland: "No! I believe the process of innovation needs to be streamlined so that new materials can be evaluated and considered against established standards, without the small manufacturers having to assume large development costs without the assurance that the product will meet an existing or a new standard."

Summary - Response to Question 1

The views on whether or not building codes unduly restrict innovations are therefore mixed, although the majority considered that they were not. Most of these referred to the equivalency provisions in Part 2 of the NBC. Two, however, considered that the NBC did restrict innovations, with one suggesting that equivalency was too difficult to prove and the other suggesting that code complexity was part of the problem. Although a third authority also concurred, it was thought that the answer depended on the code. One province had no opinion to offer since codes were administered locally.

Question 2: Do you consider that innovation in construction would be facilitated if the building regulations were more performance oriented?

B. C.: "Again, I would agree, if there is a review of the total picture including code content, format and complexity, and education."

Alberta: "With the equivalency sections in the code, we do have a performance code for the major part allowing the performance intended to be met in any fashion a designer wishes that provides the level of safety required in the code."

From sixteen years of experience approving products at a provincial level, I see the problem classed as ranging from: gross ignorance of any concept of safety on the part of an inventor who feels no obligation to research the limits or restrictions on his product to slightly less ignorance on the part of many inspectors who do not understand the fundamentals of code requirements well enough to evaluate if the principals involved are being met. The real problem is more one of education than one of code style and would not have been much of an issue if all provinces had been providing equivalence provisions in their codes as Alberta has since it first implemented a provincial code."

Saskatchewan: "Building regulations cannot be more performance oriented at this time. This may be considered desirable but we must first raise the assessment ability of building inspectors across the country so that they are able to assess proposals prior to issuing permits."

Manitoba: "Our Department is of the opinion that new innovations in the construction industry would be facilitated if the National Building Code was a more performance orientated code."

Ontario: "When building regulations are stated in performance rather than prescriptive terms they are less inhibiting with respect to innovation."

It is widely recognized that performance standards, by stating clearly and in quantitative terms where possible, what the Building Code is attempting to achieve, do facilitate innovation. Even though some Building Codes allow for the use of "equivalents", when requirements are stated in prescriptive language the innovator must try to infer from the prescriptive requirements, what kinds of performance levels the Building Code is really asking for. On the other hand, if Code objectives are stated in performance language the innovator knows what performance levels the Code requires for various building systems and designers are encouraged/facilitated in seeking out innovative alternatives.

Furthermore, if the Code is written in performance terms, the innovator along with building officials and bodies involved in materials and building systems testing, can more readily determine if the innovative building system/material meets the intent of the Code. Of course testing by standards organizations and evaluation by design professionals would still be required but their task would be made easier if the intent of the Code is clearly stated.

By making it easier, and presumably less expensive, to demonstrate/establish Building Code compliance, performance standards do facilitate innovation in construction.

While much of the Code is already performance oriented, there are areas of the Code that may be weak in this respect, for example requirements related to the building envelope. The extent to which the Ontario Building Code is performance oriented in comparison with other codes (i.e., U. S. [BOCA], Scandinavian, European, etc.) is something which I think should be investigated."

Quebec: "Évidemment, qu'il en serait ainsi. Néanmoins, le but d'une réglementation est d'abord de rendre obligatoires des techniques et pratiques reconnues saines et sécuritaires et non pas de promouvoir de nouvelles approches. Cette dernière promotion doit être faite par d'autres qui doivent démontrer que l'innovation rencontre l'objectif du règlement. Nous croyons que l'exemple récent de l'isolant en mousse d'urée formaldéhyde devrait nous inspirer quelque prudence."

N. B.: "Unable to answer as regulations are administered by each city, town or municipality."

Nova Scotia: "No. Code and Regulations presently satisfactory."

P. E. I.: "One can design within Codes and Standards and still be innovative. Surely performance oriented materials would still be required to meet a standard which could be considered restrictive by some innovators."

Newfoundland: "It is difficult to be specific on this point, some things lend themselves to performance oriented regulations and others do not."

Summary - Responses to Question 2

There is no real consensus as to whether innovations would be facilitated if the NBC was more performance oriented, although the majority thought that they would be. One qualified this by noting that content, format, complexity and education also should be addressed. Another pointed out that the main concern of codes should be health and safety and not the promotion of innovations. It is of interest to note that in answering this question, three authorities independently raised the issue of educational needs.

Question 3: Does your province require a formal evaluation for all new products, or is this handled to a large extent at the local level on a more informal basis?

B. C.: "This is handled at the local level, but we are studying the introduction of a provincial material evaluation program."

Alberta: "Product approval in Alberta can occur at the local level on a project by project basis or on a province-wide basis through the Department of Labour. Most manufacturers/suppliers seek a provincial market and approval and frequently local inspectors request provincial approval before they will accept new products. All inspectors throughout the Province are notified monthly of new provincial approvals or of the change in status of an approval."

Saskatchewan: "No. Enforcement of building regulations is by municipalities and we recommend use of the services provided by the Canadian Construction Materials Centre."

Manitoba: "Presently, our Province does not require a formal evaluation for all new products or systems. The acceptance of a new product is left to the authority having jurisdiction for the specific area of the Province in which the product or system is to be installed."

Ontario: "In Ontario, new products or systems for buildings governed by Part 9 of the Building Code may be approved at the local level by the chief building official pursuant to Article 9.3.0.1. The Building Materials Evaluation Commission may authorize the use of new products or systems throughout Ontario, pursuant to Section 18 of the Building Code Act."

Quebec: "L'application des codes au Québec s'en tient aux spécifications qui y sont contenues. Le ministère du Travail exige de ceux qui veulent introduire de nouveaux produits ou de nouvelles techniques en lieu et place de ceux qui sont prescrits aux codes qu'ils démontrent que l'objectif de sécurité est pleinement rencontré, à la satisfaction du Ministère."

N. B.: "All three codes administered rely on the approval process of CSA, ULC, Warnock-Hersey, Canadian Gas Association."

Nova Scotia: "No, not at the present time."

P. E. I.: "No."

Newfoundland: "This province largely utilizes material in construction that meets existing National Standards. We believe that new and innovative materials need to be encouraged by incentives of some kind to potential manufacturers."

Summary - Response to Question 3

Three provinces indicated that evaluation of innovations took place at the provincial level. (Two of these noted that approval could also occur at the local level.) In all other cases, evaluation was at the local level.

Question 4: Do you maintain a formal educational program for training or upgrading the technical level of building officials or is this left to the other agencies?

B. C. "As yet, there is no formal educational program at the provincial level although this is an issue that must be addressed sooner rather than later."

Alberta: "Alberta has an active building inspector training program and a voluntary certification program which will become mandatory in a couple of years. Once mandatory, existing non certified inspectors will be given five years to get certified as a grandfathering concession."

Saskatchewan: "The Saskatchewan Building Officials Association have accepted building inspector training as their mandate."

Manitoba: "Presently, a formal education program for building officials has not been established in this Province. There has been a survey sent out to the building

officials and the construction industry to determine the need and scope of any educational program."

Ontario: "In 1990-91, the Buildings Branch is sponsoring over 70 Building Code courses for building officials, builders and designers. We are enclosing our 1990-91 Course Calendar for your information."

Quebec: "Le Ministère met sur pied périodiquement des programmes de formation à L'intention de ses inspecteurs afin de leur transmettre toute information sur les codes qu'ils administrent: cette formation vise d'abord à rencontrer la mission du Ministère."

New Brunswick: "The Department of Labour through New Brunswick Community Colleges have developed a Combination Inspectors Training Program for Electrical/Plumbing/Structural and are currently developing a Fire Prevention Training Course. In-house training is also carried out through the Chief Inspectors of the Department."

Nova Scotia: "Our department presently offers semi-annual training courses, we are intending however, to increase the frequency of such courses and also make them available to all people in the building design and construction industry."

P. E. I.: "No."

Newfoundland: "Formal training of Building Technical Officials through seminars and educational programs is not done through a regular basis and certainly leaves much room for improvement."

Summary - Response to Question 4

Five provinces indicate that they sponsor training courses for building inspectors. In at least two of the provinces that do not sponsor such courses, the Building Inspectors Association have assumed the responsibility."

Question 5: What services are provided on a provincial level to assist local enforcement officials in matters such as code interpretation?

B. C.: "The Building Standards Branch provides technical assistance to local authorities and other code users by offering opinions on code matters, holding workshops and issuing bulletins."

Alberta: "The following are some of the services provided at a Provincial level to building inspectors relative to code interpretation:

- 1) Phone advice (toll-free if desired) from regional offices or head office.
- 2) Written advice
 - a) letters
 - b) published bulletins
 - i) rulings (mandatory)
 - ii) interpretations (mandatory)
 - iii) information (not mandatory)
- 3) Seminars, workshops and training courses (correspondence and classroom)
- 4) Major participation in Building Officials' conferences (two per year)
- 5) Computer programs."

Saskatchewan: "Assistance in code interpretation and advice in administration and enforcement of building regulations is provided to all building inspectors by this department."

Manitoba: "If any local enforcement official is in need of assistance in matters such as code interpretation, there are provincial officials who are available to provide such assistance as deemed appropriate."

Ontario: "The Buildings Branch provides assistance to local enforcement officials by:

- (a) providing advice and interpretation of the Building Code, Plumbing Code and Building Code Act;
- (b) visiting municipalities on a regular basis and visiting construction sites at a building official's request to analyze and assist in resolving problems relating to Code requirements;
- (c) organizing workshops and seminars to increase the awareness of building officials on technical code related issues;
- (d) assisting in preparing municipal by-laws for building, plumbing and the appointment of inspectors;
- (e) assisting in the establishment of new building departments and the restructuring of existing departments;
- (f) providing orientation sessions for new chief building officials on processing building permits, enforcement procedures and filing systems;
- (g) organizing seminars for elected and appointed officials and technical groups on a wide range of technical and building administration subjects;
- (h) conducting comprehensive administrative studies for municipal building departments to improve their efficiency and effectiveness; and
- (i) providing funding for innovative proposals to improve the processing of building permits, to refine inspection procedures, to upgrade building records maintenance or to share services with neighbouring municipalities."

Quebec: "Sur demande, le Ministère peut accorder son support aux municipalités, s'il s'agit d'une juridiction provinciale. Cependant, les municipalités ont des juridictions généralement séparées de celles de l'État qui n'est alors tenu à aucun support particulier. Les municipalités sont regroupées en associations qui se penchent sur les problèmes de leur ressort."

New Brunswick: "The inspectors and Chief Inspectors provide all code interpretations."

P. E. I.: "None."

Newfoundland: "Very little."

Summary - Response to Question 5

The degree of provincial services provided to assist local authorities varies considerably from province to province. Some provinces provide comprehensive services while others provide little or no support services.

Question 6: Will the evaluation services offered by the Canadian Construction Materials Centre at NRC's Institute for Research in Construction have any effect in facilitating the introduction of new materials and systems in your jurisdiction?

B. C.: "I believe that the CCMC will have an effect in introducing new materials and systems although to what degree remains to be seen; much will depend on the quality of the service."

Alberta: "Our longer term objective is full utilization of CCMC's services. We are in touch currently and trying to work out the wrinkles to get the service to the level we need to feel comfortable with it. Our efforts will be more and more to steer existing and new clients toward CCMC as time passes. When everything is operating smoothly CCMC reports will have automatic acceptance in Alberta."

Saskatchewan: "Yes. (Enforcement of building regulations is by municipalities and we recommend use of the services provided by the Canadian Construction Materials Centre."

Manitoba: "The evaluation services offered by the Canadian Construction Materials Centre is presently viewed by the Province of Manitoba as providing part of an accepted approval process for those individuals who wish to introduce new materials or systems in the Province of Manitoba."

Ontario: "I think that the new Canadian Construction Materials Centre will probably have a positive impact in facilitating the introduction of new materials and building systems in Canada. I would also add that the development of performance equivalents for those portions of the Building Code which are written in prescriptive language will assist the CCMC in undertaking its work."

Quebec: "Cette influence sera minime selon l'expérience accumulée. S'il en est, ce ne peut être qu'indirectement lorsque des promoteurs auront à démontrer que ces produits ou systèmes respectent l'objectif de sécurité du public, ou par l'intermédiaire de nouveaux codes, d'abord étudiés par des comités d'experts, et éventuellement adoptés par les autorités gouvernementales."

New Brunswick: "The evaluation services offered by the Canadian Construction Materials Centre will affect the introduction of new materials or systems through our utilization of CSA, ULC, Warnock-Hersey and the Canadian Gas Association or through adoption of these evaluation services as they may relate to the applicable codes administered by this department."

Nova Scotia: "Yes, N. R. C.'s Institute for Research in Construction is a well respected organization and their opinions are certainly considered."

P. E. I.: "No."

Newfoundland: "I believe it will provide these incentives for manufacturers to use it."

Summary - Response to Question 6

Most provinces believe that the services provided by CCMC will have an effect on facilitating the introduction of innovations. Two provinces thought that such a service will make little difference (at least in the short term).

Question 7: When a new code edition is considered for adoption is it subject to a review process to accommodate your regional concerns?

B. C.: "British Columbia adopted an open code change process in preparing the current edition of the B. C. Building Code. The concept received unanimous support from all sectors of the building industry and we will be embarking on the same open code change process for the next edition of our Code."

Alberta: "When Alberta adopts a new edition of the NBC there are a few changes but mostly additions for areas not covered or not covered adequately. Our official position is that we are asking comment on those changes and additions, not the whole NBC since we actively promote participation in the NBC public review process; however, we cannot ignore a strong protest on something that might arise. This would then be dealt with in the light of the agreement Alberta is committed to which limits changes to as few as possible. The reasons for change would have to be substantial."

Saskatchewan: "Yes - the review process is by this department with input by the public continuously sought. We do not consider that resources available make possible a public review process such as is provided by NRC or that it is warranted."

Manitoba: "When the proposed 1990 National Building Code was being considered by the Building Standards Board of Manitoba, only those amendments deemed necessary to reflect local conditions were considered for inclusion in the new 1990 Manitoba Building Code. A similar process was also followed for the 1990 Manitoba Plumbing and Fire codes."

Ontario: "The 1990 edition Ontario Building Code was subject to a review process to accommodate regional concerns."

Quebec: "Le Ministère a pour objectif d'adopter les codes nationaux avec un minimum de modifications. Aussi participe-t-il activement ou tout au moins émet-il des commentaires inspirés de ses préoccupations. A défaut d'obtenir satisfaction,

alors là seulement procède-t-il à des modifications. Donc, il y a un processus de révision pour refléter les intérêts régionaux."

New Brunswick: "New code additions are always reviewed and have always been accepted to this point."

Nova Scotia: "Yes, the new Code is, however, expected to be adopted with only minor revisions and/or additions."

P. E. I.: "No."

Newfoundland: "Not on any organized basis to allow input from those involved in the construction industry in this province."

Summary - Response to Question 7

All provinces except two have a process to review each new edition of the Code to reflect regional interests. There seems to be an attempt in most cases, however, to keep additional revisions to the NBC to a minimum. In only two provinces (both without provincial codes) is no automatic review carried out.

APPENDIX B

USE OF THE NATIONAL BUILDING CODE IN CANADA

APPENDIX B

NATIONAL BUILDING CODE OF CANADA USE BY THE PROVINCES

1. British Columbia officially adopts the NBC by reference and publishes it as the B. C. Building Code (BCBC). Except in the City of Vancouver, the latest version of the BCBC is the only building code that may be used by municipalities that choose to adopt and enforce a building bylaw (most do). THE Vancouver Building Bylaw is based on the NBC plus the BCBC changes plus Vancouver's own changes. Among the provincial building codes, it is estimated that the BCBC is second only to the Ontario Building Code in the number of changes made to the NBC.
2. Alberta officially adopts the NBC by reference and publishes it as the Alberta Building Code (ABC). The ABC applies throughout Alberta without local change. The ABC includes a relatively small number of changes from the NBC. It also contains a large number of additions to expand its scope so that it consolidates all provincial building requirements into one regulation.
3. Saskatchewan officially adopts the NBC by reference, with relatively few changes from the NBC, and requires its use throughout the province without local change. Section 3.7 on barrier free access has been substantially rewritten.
4. Manitoba officially adopts the NBC by reference and publishes it as the Manitoba Building Code (MBC). The MBC applies throughout Manitoba without local change. The MBC includes a number of changes from the NBC.
5. Ontario does not reference the NBC in its legislation but the Ontario Building Code (OBC) is based on the NBC, with changes. The OBC applies throughout Ontario without local change. Among the provincial building codes, it is estimated that the OBC makes the greatest number of changes to the NBC. A new Part 11 on renovation has been added.
6. Quebec officially adopts the NBC by reference, with few changes, and requires its use throughout the province. Local bylaws have jurisdiction over all buildings. Their requirements for public buildings, however, may not reduce the minimums of the QBC. The QBC does not apply to 1-or-2-storey residential buildings with fewer than eight attached dwelling units. To regulate residential construction, most municipalities have adopted local building bylaws based on the NBC, with the exception of the City of Montreal which has its own regulations, originally based on the New York City Construction Code.

7. New Brunswick does not have a provincial building code but does require that any municipal building bylaw must adopt the NBC by reference without local change. The province automatically updates such bylaws annually by Order in Council to reflect revisions or new editions of the NBC. Draft legislation has been prepared that would enact the Building Construction and Inspection Act adopting the NBC without provision for local change.
8. Prince Edward island does not have a provincial building code and has no special requirements relative to municipal building bylaws. The larger communities have individually adopted the NBC.
9. Nova Scotia officially adopts the NBC by reference, with relatively few changes, and requires its use throughout the province. Local changes are possible but they cannot be inconsistent with the NBC and provincial regulations.
10. Newfoundland does not have a provincial building code but does require that any municipal building bylaw must have provincial approval and must adopt the NBC by reference without local change. The province automatically updates such bylaws annually by Order in Council to reflect revisions or new editions of the NBC. The province encourages municipalities to adopt building bylaws.

APPENDIX C

PART 9, 1965 NATIONAL BUILDING CODE

PART 9 - HOUSING

SECTION 9.1 GENERAL

9.1.1. The requirements of Part 9 shall apply to the design, construction and the alteration of houses and apartment buildings.

Application

9.1.2. In this Part where the term "good practice" is used the appropriate provisions in the Residential Standards as published by the National Research Council shall be used as a guide by the authority having jurisdiction to satisfy the requirement. (References of this kind in this Part are marked thus**.)

9.1.3. A building shall be designed in such a manner that under the conditions of design loading, permissible material stresses will not be exceeded.

Design

9.1.4. The sizes of members transferring loads shall be determined in accordance with good practice**.

9.1.5. All materials shall possess the essential properties necessary to perform their intended functions in the structure. All materials, including used materials, shall conform to appropriate standard specifications such as are included in the Residential Standards published by the National Research Council.

Materials and specifications

9.1.6. Materials, methods and equipment not specified in this Part are permitted provided that their suitability has been established to the satisfaction of the authority having jurisdiction

- (a) by test
- (b) by actual performance, or
- (c) according to recognized engineering principles.

9.1.7. Where approval for material, methods or equipment is to be based on tests, the test methods shall,

Test methods for materials and equipment

- (a) be those published by a recognized agency
- (b) where no published test methods exist
 - (i) tests shall be designed to simulate or exceed anticipated service conditions, or
 - (ii) tests shall be designed to compare the performance of a material or component with an approved material or component for the same intended use in the building that has given satisfactory service.

Tests shall be carried out by a testing laboratory acceptable to the authority having jurisdiction.

Workmanship

9.1.8. Workmanship of a standard equal to good building practice is required by this Part.

Drawings and Specifications

9.1.9. Where required by the authority having jurisdiction, drawings and specifications shall be submitted for each building or group of buildings as required in NBC 1.5.5.(d).

Drawings required

Construction Safety Measures

9.1.10. Precautions shall be taken at all times during construction to provide safety for the public and workmen as required in accordance with good practice.**

* Words in italics are defined in Section 9.2 or in Part 1.

** See Subsection 9.1.2.

Design & Construction

9.1.11. Any requirements for the design and construction of *houses* and *apartment buildings* not contained in this Part shall be deemed to be adequately covered if in conformity with good practice.**

SECTION 9.2 DEFINITIONS

9.2.1. "*Apartment Building*" means a type of multiple dwelling comprising of three or more dwelling units with shared entrances and other essential facilities and services and with shared exit facilities above the first storey.

9.2.2. "*Dwelling unit*" means two or more rooms used or intended for the domestic use of one or more individuals living as a single housekeeping unit, with cooking, eating, living, sleeping and sanitary facilities.

9.2.3. "*House*" means a building other than an *apartment building* that contains one or more dwelling units provided that there is not more than one dwelling unit above another, and there are not more than 2 storeys above the top of a foundation where the building contains more than one dwelling unit.

SECTION 9.3 BUILDING PLANNING

Space
dimensions

9.3.1. The dimensions of all spaces in *houses* and *apartment buildings* that are intended for human use such as room sizes and dimensions, ceiling heights and doorway dimensions shall be in accordance with good practice.**

Exits

Number
of exits
required

9.3.2.(1) Where there is one or more than one dwelling unit in a house each dwelling unit shall have

- (a) one exit that serves only the one dwelling unit, or
- (b) at least two separate and independent exits
 - (i) both of which are common to two or more dwelling units, or
 - (ii) one of which is common to two or more dwelling units and the other of which is an exterior stair.

Location of
an exit

- (2) An exit as required by Article 9.3.2.(1) shall not pass through
 - (a) an attached or built-in garage, or
 - (b) a room or dwelling unit not under the immediate control of the occupants of the first dwelling unit.

Width of
exit

- (3) The minimum width of exits shall be in accordance with good practice.**

Doors in
stairs and
exits

- (4) Where a door swings toward a stair, the full arc of its swing shall be over a landing at the top or bottom of a stair.
- (5) All doors in exits and access to exits shall open in the direction of travel to the exterior.

Exits in
apartment
buildings

- (6) In addition to the requirements for houses in 9.3.2.(2), additional requirements for exits and access to exits shall be in accordance with good practice.**

Access to Attic and Crawl Space

- (7) At least one opening shall be provided as access to every attic or crawl space in accordance with good practice.**

SECTION 9.4 FIRE PROTECTION

9.4.1. Appropriate requirements for the protection of life in the event of fire and to restrict the spread of fire throughout the building or to other buildings shall be in accordance with good practice.**

** See Subsection 9.1.2.

SECTION 9.5 EXCAVATIONS

9.5.1. Where excavations are made and back filling is placed as part of the work of constructing a *foundation* for a *building*, the work shall be done in conformance with good practice.**

SECTION 9.6 FOUNDATIONS

9.6.1. A *building* shall be adequately supported by *foundations* according to good practice.**

9.6.2. *Foundations* shall be interpreted to include footings and piling, walls, posts, *piers*, *pilasters*, rafts, slabs, grade beams, grillages or design forms which extend below *grade* for the purpose of supporting the *building* on the ground.

Interpretation

9.6.3. Footings shall be proportioned according to good practice** to ensure a minimum of differential movement.

Footings

9.6.4.(1) Except as permitted in Sentence (2), footings shall rest on undisturbed soil or rock.

(2) Footings may be supported on consolidated fill or unstable soil provided the footings are designed for existing conditions in a manner acceptable to the authority having jurisdiction.

Soil under footings

SECTION 9.7 DAMPPROOFING, WATERPROOFING AND DRAINAGE

9.7.1. *Foundation* walls, floors of *basements* or *cellars*, slabs on grade, and crawl spaces shall be constructed to resist the passage of water and water vapour in accordance with good practice.**

9.7.2. Unless otherwise permitted by the authority having jurisdiction, all exterior *foundation* walls and crawl spaces shall be drained in accordance with good practice.

SECTION 9.8 MASONRY

9.8.1. All materials used for *masonry* units and cementitious materials shall conform with the requirements of 9.1.5.

Materials

9.8.2. Mortar mixes shall be proportioned in accordance with good practice.**

9.8.3. All *masonry* walls shall be supported on *masonry*, *concrete* or steel.

9.8.4. Every *masonry* wall shall be designed and constructed to resist the imposed loads, and in no case shall the thickness of solid exterior walls, *cavity* walls, *masonry* veneer, interior load bearing *masonry* *partitions* and walls and interior non load bearing *partitions* and walls and *parapet* walls be less than the minimum good practice.**

Thickness

9.8.5. Adequate support in accordance with good practice** shall be provided for joists, rafters, beams, columns or any other member which bears on *masonry* and carries a concentration of load.

Support of load-bearing members

9.8.6. All details of *masonry* construction including such features as flashing, connections and caulking shall be in accordance with good practice.**

Flashing and caulking

SECTION 9.9 WOOD FRAME CONSTRUCTION

9.9.1. All material for *wood frame* construction including used lumber shall conform to the requirements of 9.1.5.

Materials

9.9.2. All members shall be so framed, anchored, fastened, tied and braced together to provide the strength and rigidity necessary for the purpose for which they are used and in accordance with good practice.**

** See subsection 9.1.2.

	9.9.3. Framing members shall not be notched or drilled other than in accordance with good practice.**
Prevention of decay	9.9.4. Ends of joists or beams and other members framing into masonry or concrete at or below grade shall be treated with preservative or designed in accordance with good practice** to prevent decay.
	SECTION 9.10 VAPOUR BARRIER
Vapour barrier required	9.10.1. All insulation of a type which when installed do not effectively limit the passage of water vapour over the entire surface shall be protected in accordance with good practice,** with a vapour barrier located on the warm side of the insulation as near the interior surface as possible.
	SECTION 9.11 ROOFING
	9.11.1. All roofs shall be protected with roof covering in accordance with good practice,** including flashing where necessary to be installed so as to (a) shed rain, and (b) prevent water due to ice damming or other causes from entering the roof.
	SECTION 9.12 SIDING
	9.12.1. Exterior walls shall be protected with a siding in accordance with good practice** including flashing and trim where necessary which shall provide a reasonably durable surface and shall shed water.
	SECTION 9.13 INTERIOR WALLS, CEILING FINISH
Finish	9.13.1. Interior walls and ceilings shall be provided with a finish which shall provide a reasonably durable surface in accordance with good practice.**
	SECTION 9.14 FLOORS
Finish	9.14.1. All floors shall be finished in accordance with good practice** for the type and kind of material selected.
	SECTION 9.15 WINDOWS
	9.15.1. Windows shall be of an acceptable design and installed in accordance with good practice.** All glass areas shall be designed to withstand the wind pressure which may be expected, and the glass thickness shall be in accordance with good practice.**
	9.15.2. A living room, dining room or bedroom, or a room composed of combinations of any of the fore-named rooms with each other or with others not mentioned, shall have a window or windows that (a) have an aggregate unobstructed glass area not less than that prescribed by good practice** (b) face directly on a street, yard or court, and (c) are unobstructed in accordance with good practice.**
Rooms requiring windows Size and location	
	SECTION 9.16 STAIRS
	9.16.1. Every stair shall be designed and constructed in accordance with good practice.**
	SECTION 9.17 PLUMBING
Scope and materials	9.17.1. Unless otherwise permitted by the authority having jurisdiction plumbing facilities as required shall be provided for every dwelling unit. The material and installation of a plumbing system shall comply with, (a) appropriate Provincial statutes, or in their absence (b) Part 7, National Building Code of Canada.

** See Subsection 9.1.3.

Sanitary Facilities

9.17.2.(1) Where there is a piped water supply every dwelling unit shall be provided with at least one kitchen sink, water closet, wash basin, and bathtub.

Required plumbing fixtures

(2) Where there is no piped water supply, a sanitary privy, chemical closet, or other means approved by the authority having jurisdiction for waste disposal shall be provided.

9.17.3. Where a piped supply of potable water is available the plumbing fixtures for a dwelling unit shall be connected to

Connection to piped potable water supply

(a) the water supply system, and

(b) either a sanitary sewer or an individual sewage disposal system.

9.17.4. Where a means of heating water is provided in a water supply system, piping shall be installed to connect the heated water with a kitchen sink, a wash basin and a bathtub.

Hot water supply

SECTION 9.18 VENTILATION

9.18.1. A habitable room or series of habitable spaces in a dwelling unit shall be ventilated by natural or mechanical means in accordance with good practice.**

Natural ventilation

9.18.2. Where a habitable room, or series of habitable spaces, is ventilated by mechanical means the system of mechanical ventilation shall be capable of producing at least one air change per hour.

Mechanical ventilation

9.18.3. A space that contains a heating unit shall have natural or mechanical means of supplying the required combustion air.

SECTION 9.19 HEATING

9.19.1. All buildings shall be equipped with heating devices of sufficient capacity to maintain the desired indoor temperature in accordance with good practice.**

Capacity of heating device

9.19.2. All heating equipment including chimneys and fireplaces shall be designed, constructed and installed in accordance with good practice,** and with the following specifications as applicable:

Installation of heating devices

(a) "Code for the Construction and Inspection of Boilers and Pressure Vessels," CSA B51-1965 published by the Canadian Standards Association,

(b) "Installation Code for Oil-Burning Equipment," CSA B139-1962, published by the Canadian Standards Association,

(c) "Installation Code for Gas-Burning Appliances and Equipment" CSA B149-1966 published by the Canadian Standards Association,

(d) "Canadian Electrical Code," CSA C22.1-1966 published by the Canadian Standards Association.

SECTION 9.20 ELECTRICAL SERVICES

9.20.1. Unless otherwise permitted by the authority having jurisdiction electrical facilities shall be provided for every dwelling unit and public spaces in accordance with good practice.**

9.20.2. Electrical facilities shall have sufficient capacity to provide, without overloading, electrical energy for the lighting and appliance outlets provided in the plans and specifications for the building.

Capacity

** See Subsection 9.1.3.

Installation

9.20.3. Electrical installation shall meet

- (a) the requirements of the appropriate Provincial or Municipal statutes, or in the absence of such statutes,
- (b) the requirements of the Canadian Electrical Code, 1966 Edition, Part 1, C22.1, published by the Canadian Standards Association.

9.20.4. Where electric service is supplied, means of providing illumination shall be installed in accordance with good practice.**

SECTION 9.21 ELEVATORS

9.21.1. Where elevators are installed in a building the equipment and installation shall be in accordance with good practice.**

** See Subsection 9.1.3.

APPENDIX D

PART 5, 1990 NATIONAL BUILDING CODE



Part 5

Wind, Water and Vapour Protection

Section 5.1 General

5.1.1. Scope

5.1.1.1. The scope of this Part shall be as described in Section 2.1.

5.1.2. Application

5.1.2.1. This Part applies to the design of a *building* assembly such as a wall, floor, roof, floor-ceiling combination or roof-ceiling combination with respect to the control of *groundwater*, condensation and the penetration of wind and rain.

5.1.3. Definitions

5.1.3.1. Words that appear in italics are defined in Part 1.

5.1.4. Other Design and Structural Requirements

5.1.4.1. The design and structural requirements of other Parts of this Code shall apply.

Section 5.2 Control of Vapour Diffusion

5.2.1. Vapour Barriers

5.2.1.1. Where a *building* assembly that would be adversely affected by condensation will be subjected to a temperature differential and a differential in water vapour pressure, the assembly shall have a continuous vapour barrier at a location that will prevent condensation within the assembly.

5.2.2. Assemblies with Low Permeance Exterior Components

5.2.2.1. Protection

- (1) Where a material or combination of materials that have a resistance to water vapour flow equivalent to that of a vapour barrier are used on the low vapour pressure side of the material that has the major thermal resistance in a *building* assembly
- (a) a continuous vapour barrier, for use in above-grade *building* construction, shall be installed on the high vapour pressure side, and
 - (b) an air space ventilated to the outside or other method of equal effectiveness shall be provided for removing the water vapour that may pass from the high vapour pressure side through the material with the major thermal resistance (see Section 2.5.).

Section 5.3 Control of Air Leakage

5.3.1. Air Barriers

5.3.1.1. Locations

(1) Where a *building* assembly will be subjected to a temperature differential, a differential in water vapour pressure and a differential in air pressure due to stack effect, mechanical systems or wind, the assembly shall be designed to provide an effective barrier to air exfiltration and infiltration, at a

5.3.1.1.

location that will prevent condensation within the assembly, through

- (a) the materials of the assembly,
- (b) joints in the assembly,
- (c) joints in components of the assembly, and
- (d) junctions with other building elements.

Section 5.4 Control of Rain Penetration

5.4.1. Joints

5.4.1.1. Joints in *exterior cladding* and the junctions of different *exterior claddings* shall be constructed to minimize the entrance of rain water into the *building assembly*.

5.4.2. Openings

5.4.2.1. An opening in an exterior wall or roof shall be so constructed as to prevent the entrance of rain or snow into the *building*.

5.4.3. Roofing

5.4.3.1. Installation

- (1) Roofing shall be installed so as to
 - (a) shed or drain water effectively,
 - (b) reduce the likelihood, when the roofing is comprised of overlapping units, of water backing up under the units due to ice damming or other cause, and
 - (c) be resistant to damage due to wind.

5.4.4. Parapets

5.4.4.1. Protection

- (1) Where the top of a wall is exposed to the weather
 - (a) it shall be capped, and
 - (b) a through-wall flashing shall be installed immediately under a segmented or pervious cap, and at such other points in the wall as are necessary to divert rain-water to the outside.

5.4.5. Exterior Wall Cladding

5.4.5.1. Exterior wall cladding shall be so installed that it sheds water to prevent its entry into other components of the *building assembly*. Where there is a likelihood of some penetration, drainage shall be provided to take water to the outside.

Section 5.5 Control of Groundwater

5.5.1. Through-Wall Flashing

5.5.1.1. Where moisture from the ground can move upward into a wall and cause deterioration of the materials in the wall assembly, a through-wall flashing shall be installed in the wall below the materials likely to be so affected.

5.5.2. Dampproofing and Waterproofing

5.5.2.1. The portion of an exterior *basement* wall below ground level or any floor slab in contact with the ground shall be dampproofed or waterproofed as appropriate. (See Appendix A.)

5.5.3. Crawl Spaces

5.5.3.1. Ground Cover. Crawl spaces shall be provided with a ground cover. (See Appendix A.)

5.5.3.2. Slope. Unless *groundwater* levels and site conditions are such that water will not accumulate in the crawl space, the crawl space shall be sloped to drain to a sewer, ditch or dry well.

Section 5.6 Materials

5.6.1. Specifications

5.6.1.1. Materials used for *exterior claddings*, vapour barriers, air barriers, flashings, thermal insulation or fastening devices shall comply with the appropriate standards listed in Part 2. (See Appendix A.)

5.6.2. Deterioration

5.6.2.1. A material exposed to corrosive conditions shall be corrosion-resistant or shall be resistant to deterioration under those conditions.

5.6.3. Fastening Devices

5.6.3.1. Fastening devices shall be made of a material which is compatible with the materials to be so joined and shall be resistant to the type of corrosion likely to be present.

Section 5.7 Practices

5.7.1. Installation

5.7.1.1. General. *Exterior claddings*, vapour barriers, air barriers, thermal insulation, sheathing papers, flashings and fastening devices shall be installed in such a manner as to effectively perform their intended functions. (See Appendix A.)

5.7.1.2. Glass. Glass shall be designed and installed to resist the loads specified in Section 4.1. (See Appendix A.)

5.7.1.3. Exterior Cladding

(1) *Exterior cladding* shall be securely fastened to backing that is

- (a) an integral structural element of a *building*, or
- (b) an element added to the structure for the purpose of supporting such *exterior cladding*.

(2) Backing for *exterior cladding* as provided for in Sentence (1) shall be suitably located, secured and of a kind suitable for the type of fasteners to be used for attachment.

(3) *Exterior cladding* shall be designed, constructed and attached so as to accommodate stresses and deformations within the structure, the cladding system and all points of attachment caused by wind, earthquake and temperature effects. (See Appendix A.)

APPENDIX E

REPORT ON THE CANADIAN CONSTRUCTION MATERIALS CENTRE

APPENDIX E

Report on the Canadian Construction Materials Centre (Based on material prepared by G.L. Walt, CCMC, March, 1990)

1.0 Introduction

After many years of discussion and negotiation with the provinces and territories and Canada Mortgage and Housing Corporation, a national evaluation service was established at NRC in July, 1988 with the creation of the Canadian Construction Materials Centre. CCMC is intended to complement the services offered by member organizations of the National Standards System (NSS) primarily by evaluating innovative construction products as equivalents to those described in building codes and standards.

In establishing the Centre the following principles were considered:

- affiliation with the NSS;
- independence from any one interest in the construction industry;
- voluntary participation by manufacturers of products;
- good regional access to the program, particularly for product testing;
- minimizing existing duplication of services between CMHC and the provinces;
- serving the entire construction industry not just residential buildings;
- cost recovery; and
- support of export of products.

In addition the CCMC was expected to continue to foster the development of new standards and third party certification programs as they are warranted.

2.0 Evaluation

Evaluation is the provision of a professional opinion on the suitability of a product for its intended use. It is not intended to be approval and is not a substitute for certification.

3.0 Objectives of CCMC

The evaluation services provided by CCMC support three objectives:

- to provide technical evaluation, advisory and information services for products and uses not yet established in construction,
- to provide technical support to exporters of construction products, and
- to consolidate the product acceptance process through information and other services that supplement the product certification systems.

4.0 Organization of the Evaluation Services

The evaluation program could be regarded as having three major components: an external policy and technical committees, a professional evaluation staff, and a large support network of contacts.

The Advisory Committee on Construction Materials Evaluation (ACCME) is made up of 21 voting members and three ex-officio non-voting members. It held its first meeting on January 18th, 1990. It is now balloting its own policies and procedures and will meet in June (1990) to consider the program policies and procedures for the services offered by CCMC. Three members of the ACNBC are members of the ACCME. In addition, the Chairman of the PTCBS is an ex-officio member of the Committee.

The professional staff consists of ten engineering specialists supported by five administrative staff. The office is highly computerized with a Local Area Network. Publications are produced internally in both official languages.

The support networks used by CCMC consist of the following:

- a Regional Laboratory Support Network of 36 public and private laboratories recognized in various areas of expertise,
- the regionally based Construction Technical Advisors (CTA's) and Industrial Technology Advisors (ITA's) of NRC's Industrial Development Office,
- the inspection offices and National Office of Canada Mortgage and Housing Corporation,
- the building code offices of the provinces and territories, and
- relevant organizations in other countries including the US, Europe, Australia, and New Zealand.

5.0 Current Status of Program

Evaluation Publications

The former CMHC Evaluation Reports will be completely reformatted by the end of March (1990). Approximately 200 files will be reissued as CCMC Evaluation Reports. The remainder have either been transferred to CGSB Certification and Qualification Programs or will appear in one of two volumes of Evaluation Listings. Volume 1 is already published.

Marketing

A major marketing program to sell subscriptions to the publications is under way. The target audiences are building designers and municipal regulatory officials.

Special Publications

A Directory of Construction Product Standards and Acceptance Programs has been produced in both computer data base and hard copy versions. It lists all the standards referenced in the National Master Specification, and the three national model codes for building, plumbing and fire along with a reference to the "acceptance" process and the organization providing "acceptance", i.e., certification, qualification, evaluation, etc. A semi-annual newsletter is also planned.

6.0 Future Activities

A Memorandum of Agreement prepared by the provinces and territories is being processed for signature by NRC and the provinces and territories. Its principal intension is to eliminate duplication by seeking to have the provinces use the services of CCMC to evaluate equivalents to provincial building codes.

Further work will be undertaken to strengthen international contacts so as to support the export development role.

7.0 Impact of CCMC Services on the Preparation and Use of Building Codes

The CCMC program could have the following impact on code preparation:

- There is now a very logical place to send non-complying products for the determination of equivalency to the intent of the Code. This means that the ACNBC and its Standing Committees will not have to consider emergency revisions for single products.
- The committees may be able to add more performance related requirements to the codes as there is a means to determine performance through evaluation by CCMC.

In the administration of building product requirements in codes and related documents, the following impacts may be noted:

- There is a Canadian point for international contact in the evaluation of construction products. This is already evident through the volume of contacts in CCMC operations.
- The creation of a single national evaluation service in support of the model codes should encourage the use of a single model national code in Canada.
- There should be some better coordination, including information services, on the construction product acceptance systems through the publication and use of the new directory.

90-03-13

APPENDIX F

PERFORMANCE REQUIREMENTS FOR HIGH BUILDINGS
1975 NATIONAL BUILDING CODE

APPENDIX F

3.2.6.1.(1) This Subsection applies to

- (a) every building of Group A, D, E or F major occupancy classification that is more than
 - (i) 120 ft (36.6 m) in height, measured between *grade* and the floor level of the top storey, or
 - (ii) 60 ft (18.3 m) in height, measured between *grade* and the floor level of the top storey, and in which the cumulative or total occupant load in a building on or above any storey above *grade*, other than the first storey, divided by the number of 22-in. (559 mm) units of exit width in all exit stairs at that storey, exceeds 300 persons, and
- (b) every building containing a Group B or C major occupancy located more than 60 ft (18.3 m) above *grade*, and every building containing a floor area or part of a floor area, located above the third storey, designed or intended as a Group B occupancy for patients in bed or infirm persons.

3.2.6.2.(1) Every building shall be designed to limit the danger to occupants and firefighters from exposure to smoke in a building fire, as provided in Sentences (2) to (9).

(2) Except as provided in Sentences (5) to (8), every building shall be designed so that during a period of 2 hr after the start of a fire all floor areas that are above the lowest exit storey will not contain more than 1 per cent by volume of contaminated air from the fire floor, assuming an outdoor temperature equal to the January design temperature on a 2½ per cent basis in Table 2.2.3.A. of Part 2 of this Bylaw.

(3) Except as provided in Sentences (6) and (8), every building shall be designed so that during a fire the limit described in Sentence (2) on the movement of contaminated air into other floor areas is not exceeded in

- (a) each exit stair serving storeys above the lowest exit level, and
- (b) each exit stair serving storeys below the lowest exit level.

(4) Except as provided in Sentences (6) and (8), every building shall be designed so that during a fire the limit described in Sentence (2) on the movement of contaminated air into other floor areas is not exceeded in a shaft that contains a firefighters' elevator, as required by Article 3.2.6.4.

(The requirements of Sentences (2), (3) and (4) may be met by use of measures B, D, F, H or I described in ACNBC publication "Measures for Fire Safety in High Buildings.")

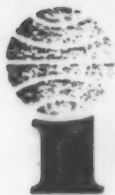
(5) The requirements of Sentence (2) are waived in a building of Group C major occupancy classification that is not more than 230 ft (76.2 m) in height measured between *grade* and the floor level of the top storey, and in any building of Group A, D, E or F major occupancy classification where occupants above the first storey can enter and be safely accommodated in floor areas or parts of floor areas that

- (a) are designated as areas of refuge on the plans and are identified as such in the building,
- (b) are located at least on every fifth storey,
- (c) provide not less than 5 sq ft (0.5 m²) of floor space per ambulatory occupant and 16 sq ft (1.5 m²) of floor space per non-ambulatory occupant,
- (d) have access corridors and doors leading to each designated part of a floor area on the same storey sufficient to provide one 22-in. (559 mm) unit of width for every 150 persons who may have to use these passages to reach the designated part of a floor area,
- (e) have access stairs from intervening storeys leading to each designated part of a floor area sufficient to provide one 22-in. (559 mm) unit of width for every 100 persons who may have to use these stairs to reach the designated part of a floor area, and
- (f) during a period of 2 hr after the start of a fire do not contain more than 1 per cent by volume of contaminated air from the fire floor, assuming an outdoor temperature equal to the January design temperature on a 2½ per cent basis in Table 2.2.3.A. of Part 2 of this Bylaw.

(In a building that falls within the scope of Sentence (5), the requirements in Sentence (5) may be met by use of Measures K or L, described in ACNBC publication "Measures for Fire Safety in High Buildings.")

APPENDIX G

**COMMENTS ON THE PERFORMANCE BUILDING CODE STUDY
BY INFORMETRICA LIMITED**



Informetrica
Limited

APPENDIX G

Mailing Address:
P.O. Box 828, Station B
Ottawa, Ontario K1P 5P9

22 February 1991

MEMORANDUM

TO: A.T. Hansen, A.T. Hansen Consulting Services
FROM: H.C. McCracken, Informetrica Limited *H.C. McCracken*
RE: Comments on the draft "A Study into Performance Building Codes"

1. The study provides convincing evidence that the National Building Code (NBC) is a complex structure, and not something that we should alter without careful thought.
2. The main route for innovations would appear to come through the evaluation process. If this is not working well, leading to suggestions to open up the NBC, it would seem more appropriate to focus efforts on improving the evaluation process. In particular, faster processing and an appeal procedure would seem to take care of most of the complaints about the code being a barrier to innovation.
3. One area that you might expand on in the executive summary is the quality of the Canadian NBC relative to that of other countries. My impression from your report is that we are second to none.
4. I would suggest that Appendix B be expanded, perhaps through a table, to bring together in one place the various provincial dimensions of the building code, training, etc. This compilation could be very useful in upcoming discussions about the reallocation of federal-provincial responsibilities that will no doubt occupy much of our time in the next several years.
5. The value to manufacturers of national standards is quite important, particularly when they operate in a small market by world standards. The current system seems to go a long way towards maintaining this national market. This in turn should be seen as a positive incentive to innovation.
6. This study is a useful and quite complete review of the NBC and the issue of performance standards. Perhaps the next step is to examine the evaluation system with the same rigour. As well, there is a sense that the administration of the code and the training of inspectors could be an area for further improvement. Again a topic for further study.